Psychological Monographs

Vol. IX
No. I

April, 1908
Whole No. 37

THE

Psychological Review

EDITED BY

J. MARK BALDWIN
JOHNS HOPKINS UNIVERSITY

HOWARD C. WARREN
PRINCETON UNIVERSITY

AND

CHARLES H. JUDD
YALE UNIVERSITY
(*Editor of the Psychological Monograph*)

Studies from the Psychological Laboratory of the University of Chicago

CONTROL PROCESSES IN MODIFIED HAND-WRITING: AN EXPERIMENTAL STUDY.

BY

JUNE E. DOWNEY

Associate Professor of English and Philosophy, University of Wyoming.

THE REVIEW PUBLISHING COMPANY
41 NORTH QUEEN ST., LANCASTER, PA.,
AND BALTIMORE, MD.

AGENTS: G. E. STECHERT & CO., LONDON (2 Star Yard, Carey St., W. C.);
LEIPZIG (Hospital Str., 10); PARIS (76 rue de Rennes).
MADRID: DANIEL JORRO (Calle de la Paz, 23).

PREFACE.

I am glad of an opportunity to express in this place my lively sense of obligation toward those whose help has made it possible for me to write the following paper.

First of all, my grateful acknowledgment is due Professor James Rowland Angell, to whose encouragement and instruction I owe not only the completion of the present piece of work but also whatever of pleasure or of profit I have derived from the study of psychology.

Again, I record with pleasure my gratitude toward those members of the Department of Psychology of the University of Chicago who so generously gave of their time and interest in serving as reagents in the experiments to be described. To Miss Florence Richardson special thanks is due, in that she served in double capacity, as subject, and, in the tests on the writer, as experimenter as well.

I desire also to express my thanks to Dr. Grace Raymond Hebard, Librarian of the University of Wyoming, for the help she has given me in the procuring of reference works and for her advice in the preparation of manuscript.

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CONTROL PROCESSES IN MODIFIED HAND-WRITING. AN EXPERIMENTAL STUDY.

INTRODUCTION.

1. The investigation recorded below was undertaken in the hope that an extensive and detailed examination of the control processes involved in some particular type of action would yield additional information relative to (1) the nature of the imagery processes in general and verbal imagery in particular; (2) the mode of functioning of these processes, their interplay in a particular concrete situation, specifically in the voluntary act of writing; (3) the relation one to the other of specific sensory processes, auditory and vocal-motor, visual and grapho-motor, vocal and grapho-motor, etc.; (4) the variational factor in the verbal imagery of individuals with its bearing upon the question of mental types in general and attention types in particular. The working out of these problems raised further questions as to the possibility of the initiation of a voluntary act without any sort of a sensorial cue and, also, questions as to the nature of mental distraction, mental lapses, and motor automatism.

As the nature of the experiment necessarily called for introspective reports, it was thought well to choose as subjects trained observers. The subjects serving were either instructors or graduate students in the department of psychology of the University of Chicago. The method used served to a certain extent to check up the reagent's introspections inasmuch as the changes introduced into the situation tended to bring about variations in the modes of response and shifts in adjustment. This method consisted in the writing of a given verse,[1] learned orally, a phrase,[2] and the reagent's name under conditions designed to throw into the foreground different control processes.

In general outline the experiments fell into three series. In

[1] The familiar rhyme, "Thirty days hath September," etc.

[2] University of Chicago.

the first series writing went on under some particular limitation of sight or movement. The subject wrote blindfolded; with left hand; formed some new coördination in writing, such as that involved in mirror-writing and in inverted writing; or wrote with the right hand in a strained position.

In the second series of experiments, writing was accompanied by a distracting process—the term 'distracting' being used here in a purely descriptive way, that carries no theoretical implications. Specifically, the distracting processes consisted in (1) an auditory-vocal-motor distraction (counting aloud); (2) a visual distraction (reading mentally); (3) a visual and auditory-vocal-motor distraction (reading aloud); (4) an auditory-vocal-motor distraction under visual limitation (counting aloud and writing blindfolded); (5) an auditory distraction (the reagent counted mentally the number of times that a particular word occurred in a rhyming list read aloud by the experimenter). In the case of each sort of distraction, except the last, attention was successively (*a*) undirected, so far as the experimental directions were concerned; (*b*) directed by the experimenter to be thrown upon the distracting process; (*c*) directed by the experimenter to be thrown upon the writing.

In the third series of experiments the effect of a time-lapse between the giving of the experimental direction and the writing of the name or phrase was tested. A description was also obtained of the various ways in which it was possible for the subject to image the act of writing the verse. The time required for various methods of ideating the verse was recorded.

Throughout the experiments conditions were kept as constant as possible. Subjects served as far as possible at a regular hour weekly. They used fountain pens, each subject keeping the same pen throughout the series; they wrote on paper of a standard quality and one size; and they maintained throughout the experiments a relatively constant position and angle for the writing pad.

Every experiment was preceded by a test of the normal writing, the speed of which was timed with a stop-watch. Writing under the conditions cited above was also timed. For the name, in addition to the normal autograph obtained each week,

a series of fifty normal autographs was obtained at one experimental session in order to get material from which to reckon the mean variation in speed and in writing amplitude that might be expected to occur during any one hour. In general, however, the time-readings in the following records make no pretense to any absolute value, the number of times any particular test was tried being too restricted to use in any such way.[3] The time-readings are instructive, however, in other connections and in particular cases check the observer's report.

2. It is proposed to begin with a general analysis of the writing-situation with the understanding that no attempt is made to deal with it genetically[4] but solely as worked out in the experiences of adults. It is to be observed, first of all, that this writing-situation is much more complicated as a voluntary act than description is accustomed to recognize. The citing of the four factors in the verbal situation, namely, the visual, articulatory, auditory, and grapho-motor word processes is descriptive of content merely. There is throughout a complication, structurally, of ideational and sensory processes; functionally, of anticipatory and report processes. Yet a preliminary statement is necessary as to the treatment of the various forms of the verbal image in present-day literature.

The verbal consciousness has been subjected to somewhat extended interrogation and in each of its so-called types to

[3] See Kaeding's discussion, including bibliography. F. W. Kaeding: *Ueber Geläufigkeitsuntersuchungen oder Feststellung der Schreibfluchtigkeit der Schriftzeichen* (1898). Kaeding, in his attempt to get at a standard unit of rapidity which could be utilized in rating the stenographic rapidity of individuals, found that the rate of work was modified by the duration and the time of writing test; by the size and such characteristics of writing as pressure on the pen, direction of movement, breaks in continuity; by practice effects; by fatigue and excitement incident to experiment; by variation in conditions during the course of the experiment. See also C. N. McAllister: 'Researches on Movements used in Writing' (*Studies from the Yale Psychological Laboratory,* VIII., pp. 21–63), in which the relative ease of upward and downward movements is discussed in its bearing upon the best movement and slant for writing.

[4] For development of writing in the child, see Baldwin: 'Mental Development,' Chap. V., sec. 2. Goldscheider: 'Physiologie und Pathologie der Handschrift,' *Archiv. f. Psychiatrie,* XXIV., 2, p. 503. Ballet: *Le Langage Intérieur,* Chap. I. For the genesis of writing in the race, see Keraval: *Le Langage Écrit.*

specific investigation.[5] Beginning with the Stricker controversy, there has been prolific discussion as to the possibility of an articulatory image uncontaminated by peripherally-aroused sensations; discussion as to the status of the auditory image as an essential or non-essential part of the articulatory image or as a possible independent existence; discussion as to the possible implication, however marginal, of visual word-imagery as a part of the content of all articulatory consciousness. Silent reading,[6] as well as silent thought, has presented its problems and raised in its turn the question whether meaning can ever attach to a pure visual image apart from motor accompaniments. Writing-consciousness which obviously involves the visual and grapho-motor word-image, also depends upon auditory-motor processes, since thinking, which (copying and dictation apart) initiates writing, usually assumes in its final outcome an articulatory form. Bawden[7] advocates the description of the types of speech consciousness under the two heads, visual-motor and auditory-motor, urging the consideration that the meaning-idea as distinguished from the pure word-idea is always motor. The bearing of the facts obtained in the present series of experiments on the points at issue will become evident as the discussion proceeds.

Meanwhile another line of argument has been opened by Professor Woodworth's conclusion[8] that a voluntary act can be initiated by a 'naked thought,' that is, one void of all sensorial content whatever. Even admitting the concept of imageless thought as thinkable, it may be urged that experimentally at least there could be no demonstration of its sole efficiency as cue to a voluntary act since the very conditions of experimentation would involve sensory material in the form of verbal directions or sense-signals of some sort. Nor even in a self-initiated voluntary act is it clear how sensorial content could be

[5] Stricker: *Sprachvorstellungen;* Ballet: *Le langage intérieur;* Egger: *La parole intérieur;* Dodge: *Die Motorischen Wortvorstellungen,* etc.

[6] Secor: 'Visual Reading,' *American Jour. of Psychol.,* XI., pp. 225–236.

[7] Bawden: 'A Study of Lapses,' *Psychol. Review,* Monograph Supplement, Vol. 3, No. 14.

[8] Woodworth: 'The Cause of a Voluntary Movement,' *Studies in Philosophy and Psychology,* Garman Commemorative Volume, pp. 351–392.

completely eliminated and naked thought isolated introspectively, since by Professor Woodworth's own showing the act is the outcome of the whole situation with all that that involves of sensory (because embodied) consciousness.

Again, Professor Woodworth's strictures[9] as to the adequacy of the image to serve as cue on the ground of its absence of distinctness and accuracy seems due to ignoring the function of the whole situation as defining and giving meaning to the cue, a concession which is by no means equivalent to saying that the situation minus the so-called cue could function in the same way that it does when it is present. The very schematism Professor Woodworth criticises in the conventional treatment of a voluntary act is evident in this inditement of the adequacy of the image, for the image, as he cites it, appears to be only an abstraction, isolated for purposes of structural analysis.

As to the relevancy at all of the kinæsthetic image as antecedent to a voluntary act Professor Woodworth is particularly sceptical,[10] since, according to his showing, such an anticipation is rarely evident to introspection and even when reported is easily impeached on the ground that consciousness has been beguiled into such a belief through a confusion of the kinæsthetic image with sensations 'of initial position or preliminary adjustment of the member' to be moved. So much may be granted. But the further contention, preparatory to denying it any function whatever, that the kinæsthetic image to be conceivable as a cue at all must 'copy' not the movement to be executed but the movement that in a sensational series would precede it and initiate it sensationally has again a schematic sound. A movement may well be initiated by an image of a movement which in a sensational series would precede it—and that too without being a useless duplicate of a sensation—just as in the act of writing the visual cue of a particular letter is often constituted not by an anticipation of the letter itself but

[9] *Op. cit.*, p. 383: "If whatever imagery may be present is less particular than my intention and than the act which results, then the image is not the adequate cue of the act." Also C. T. Burnett: 'An Experimental Test of the Classical Theory of Volition,' *Studies in Phil. and Psychol.*, Garman Commemorative Volume, pp. 392–401.

[10] For a full statement of the argument, see *op. cit.*, p. 272 f.

by the seen or imaged letter that precedes it in the habitual setting (see reports below); but, on the other hand, it is difficult to see why in a world of infinite repetitions and combinations it should be held impossible for an image to form an anticipatory association with the one movement it resembles with more or less fidelity.

It is a consequence of Professor Woodworth's general position that much of the imagery reported by observers as present in voluntary acts is held to be unnecessary and irrelevant. This raises the question, quite apart from the interpretation he puts upon the fact, as to the possible utility of seemingly superfluous imagery. Of which more later.

Apart from such difficulties in his position, Professor Woodworth's analysis of the antecedents of a voluntary act, particularly of the causal value of kinæsthetic sensations of initial position, etc., is very penetrating. Highly suggestive too is his conception[11] of a " set or adjustment, or temporary ' disposition ' " of the nervous system ' which can hold over for a while.'[12]

We proceed now to a detailed analysis of the factors which may enter into the voluntary act of writing. The analysis is based upon introspective reports on writing embarrassed by certain limitations in the hope of throwing into the foreground factors of control in a new situation, or even factors of control present in the more habitual process but apt to be overlooked by introspection. It is evident that an analysis to be complete must recognize the whole situation, concrete as well as verbal. Such recognition would demand recall of the visual aspect of the situation such as the surroundings in general and writing-tablet, hand, arm and pen in particular; it would include kinæsthetic sensations arising from the writing posture, hand-and-arm-position and eye-adjustment being important. Such factors, modified by the course of the writing, would persist throughout and might well serve in a directive capacity. Auditory elements in the form of report from the

[11] *Op. cit.*, p. 389 f.

[12] Relative to this holding over of the nervous set, see Experiment 1, Part III., below.

moving pen, or, in the experimental situation, of signals given aurally would also enter.

From the verbal side analysis[13] has concerned itself largely with the visual and grapho-motor processes. The hand-kinæsthetic process is obviously the '*sine qua non*' of writing as an act although not necessarily of the writing-consciousness; for one must distinguish between the writing-movement which might conceivably be a purely physiological event and the consciousness of that movement either in the form of an image of anticipation or of a sensational report of the movement as achieved, either of which might fail to assume kinæsthetic terms. A sensory kinæsthetic report on the movement as it proceeds is of course usually present, although it varies apparently in vividness and accuracy from individual to individual and has a different value for the same individual under different conditions. Its normal presence is testified to by the peculiar feeling that accompanies its lapse from consciousness. This kinæsthetic report has undoubtedly great utility as a conscious control process, probably functioning in the usual course of writing as a corrective but also at times as an initiative process as well.

The grapho-motor process as purely ideational and anticipatory has a more dubious existence and value. The difficulty found in the attempt to identify a pure articulatory image is here duplicated; while again the complication of the latter with auditory imagery is paralleled in this case by the fusion of the graphic with the visual image. As introspection on the part of certain observers has failed to disclose the existence of the hand-motor writing-image, recourse has often been had to pathological cases in which writing has remained possible in spite of verbal blindness and verbal deafness. The following reports offer some introspective evidence as to the reality and nature of the grapho-motor image; for the kinæsthetic factors, both sensational and ideational, are thrown into the foreground when the writing coördination is broken into.

[13] See particularly Ballet, *op. cit.*, pp. 54–58; Dodge, *op. cit.*, pp. 64–70; Keraval, Chap. VI. (interesting for statement of the varying value of the visual element in the writing experience of various races).

Introspection of the nature and function of the kinæsthetic factor is peculiarly difficult yet an understanding of the rôle it plays in consciousness is basal to any treatment of the meaning of automatism. From movement as clearly anticipated and reported in whatever terms, and movement as merely reported 'motorly' there are many gradations to movement which is simply physiological, and the possibility of experimentally inducing such variations in writing offers a particularly promising point of departure for a study of automatism in general.

Another general observation seems in place. Emphasis has often been laid upon the distinction between movement as a mere motor phenomenon and the kinæsthetic content of consciousness, which is as obviously sensory as any other kind of content. Yet for some reason the kinæsthetic image is still treated theoretically as carrying or implying a stronger impulse to movement than does a visual or auditory image, an assumption which only experiment can test. Moreover, throughout discussions there is in general a tendency to confuse functional and structural points of view and to pass from the conception of consciousness as sensori-motor, with all that that implies of motor value for all imagery-processes, to the assumption that every image possesses a motor content. This assumption may be true to fact since, as the image arises only in a consciousness functioning 'motorly,' in genesis and development it must be continually modified by the reaction into it of kinæsthetic material; but it is an assumption which is inadequate in so far as it ignores the fact that this content assumes very different value in the experiences of different individuals and might conceivably approach a vanishing point.[14]

The function of the visual factor in writing considered from the genetic point of view, or where new coördinations are attempted, is obvious enough. Its utility in the fully-formed writing habit is, on the other hand, held to be trifling. Introspection rarely reveals an anticipatory visual verbal image and there is a tendency to minimize the value of the visual perception of the result of the writing movement except as directive

[14] Bawden: "The terms 'Sensory' and 'Motor,'" *Psychol. Rev.*, VII., p. 390.

in the matter of spacing and alignment. Says Bawden:[15] "It is practically impossible to determine with experimental accuracy the degree to which the kinæsthetic is helped out by the visual imagery in writing."

Reference is frequently made to writing blindfolded in order to establish the slight significance of the visual element. What the discussions ignore, however, is the presence in such writing in the case of many individuals, of a distinct visual anticipation or even more often of a visual report. This second process should not be confused with the anticipatory one for when both processes are present they may show distinct differences[16] not only in vividness and spatial position but also in characteristic form or appearance. As to the meaning of the visual '*report*' in blindfolded writing, the author is inclined to think that it indicates the importance of the visual perception of the writing when the eyes are open and shows that the visual report has both a corrective and at times a cue function. At least one subject in the experiments reported below felt confident that he got his cues frequently from this visual report; and in the case of the writer, who is conscious of following writing very closely when eyes are used and who has a vivid visual report when writing blindfolded, the utility of this report is felt to range from giving confidence and keeping the movement from lapsing into an automatic one to actually constituting the cue. The distinctness with which the latter mode of functioning stands out against the ordinary case where the report is felt to be in no sense initiative is rather striking.

Dr. Raymond Dodge[17] in his brief treatment of the visual report during blindfolded writing is inclined to be sceptical of its value and considers it as a mere intensification of the visual anticipation. In certain of the reports its striking incongruity

[15] *Op. cit.*, p. 69. See also statement on p. 68. "Of course the kinæsthetic imagery can not be separated from the visual process in writing any more than from the auditory process in speech."

[16] For instance, a student volunteers the information that in writing blindfolded the visual 'report' appears about an inch to the right of the visual anticipation and is darker in color: S, see below, reports a case where the visual anticipatory imagery appeared above the writing paper, while the visual report appeared on the paper itself.

[17] Dodge, *op. cit.*, p. 65 f.

with the anticipated result makes such a general interpretation impossible. Moreover, Dr. Dodge's own visual report apparently followed the writing movement only in a general way. For certain of the writer's subjects the correspondence was so detailed that they were able to reproduce from the visual report (not the kinæsthetic) minute inequalities in the movement. The tendency for the visual element to function in this way for the kinæsthetic report is characteristic of certain individuals and suggests interesting questions as to the various types of relation between the motor and visual aspects of consciousness. These relations will become more evident as the discussion proceeds.

The writer is also led to believe that visual anticipation, which blindfolded writing throws into relief in the case of a few observers, is indicative of a certain amount of such control in normal writing, for it is found only in the case of those who make explicit use of visual anticipation in more complicated situations. Dependence upon visual anticipation and upon visual report are, it should be noticed, not necessarily found in the same individual, although dependence upon any particular sense element is apt to be a general one. In the case of certain writers, whom experiment has shown to utilize on occasion visual anticipation, the author has been interested in noticing the evident tendency to slurring or telescoping of letters after a word is once under way—as though the intention once visually realized took little account of further execution. The observation has of course only the suggestive value of a very restricted examination of such cases.

The verbal articulatory process, whether or not involving muscular innervation, and accompanied or unaccompanied by audition depending upon the individual, is also a very significant factor in the writing situation. Normally, it is clearly anticipatory of the writing movement, but under certain conditions it seems either synchronous with the writing or, at times, sequent to it, as a report. The difference between the articulatory process as the thought process and as the actual motor cue to the writing is shown in the cases where a double articulatory

process is present;[18] the first outstripping the writing and perhaps using a different verbal unit from the slower process which accompanies the writing at nearer range. Such a possible doubling of the vocal process is clearly facilitated by auditory imagery and perhaps points to the independence of such a process. In any case the significance of the articulatory process, whether indispensable or not, its qualitative characteristics and the scope of its unit are thrown into the foreground by all of the distraction experiments and by alterations in the conditions under which writing takes place.

The various 'controls' thus schematically treated enter into varied and individual combinations with one another. The fusion of vocal-motor and grapho-motor, of auditory and articulatory processes has already been emphasized as more or less evident in the case of nearly every observer. More sporadic and individual were the occasional reports as to the fusion of visual and auditory or of visual and articulatory processes. The whole situation, it should be observed, is one of great complication, a besieging of consciousness by a multitude of sensations and images, so casual and varied as to seem irresponsible, often so evanescent as to raise a question as to their effectiveness. The general problem as to the nature and functioning of consciousness itself intrudes.

3. Following this summary statement of what processes may be looked for in the situation under consideration, a general study of the imagery processes of the different observers, so far as the verbal consciousness is concerned, is presented. Greater value would attach to such studies from the standpoint of individual psychology, if they could be paralleled by a study of the functioning of the imagery processes in a situation organized on a concrete rather than a verbal basis. Unfortunately such a treatment is impossible. Nor if it were within the scope of the present paper would the writer be wise—or daring—enough to complete the study by a statement of each observer's temperamental peculiarities.

[18] Cf. the writer's experience in taking dictation where she hears mentally a sentence or two in the lecturer's voice, while vocalizing mentally in her own voice the word or phrase that she is just on the point of writing.

B. This observer had cultivated auditory imagery and auditory attention to a high degree. His usual writing-cue was strongly auditory-vocal-motor, the auditory aspect of the process being marked. The auditory aspect of the writing-report was also prominent; for instance, the sound of the pen-scratching sometimes served as a guiding process, normally so in making such letters as 'm' and 'n'; and in blindfolded writing this report gave confidence. The kinæsthetic factors of the writing, both sensational and ideational, were also marked. B was confident of the presence in certain cases of an anticipatory kinæsthetic image which seemed purely ideational as evidenced by the fact that occasionally there occurred conflicts of kinæsthetic images or conflicts between an image and the movement actually in process of making, or contemporaneousness of one movement and the image of another, the kinæsthetic cue keeping ahead of the writing (see left-hand writing). The writing process was thoroughly well automatised. B reported at times a lagging of attention behind the movement, a retardation that sometimes produced errors. Even the auditory-vocal-motor accompaniment seemed in certain tests to be largely a report, not an anticipatory process. The visual aspect of the verbal consciousness was much less in evidence. Perceptual visual control was not utilized to any extent while a visual report was very infrequent and, on occurring, inadequate. Visual accompaniments to the writing process occurred, however, in the form of concrete images of the writing situation; position of hand and paper, general alignment, etc. Again, when novel conditions demanded visual readjustments B, showed excellent control of visual imagery. (See experiment 5.)

The distraction experiments, in confirmation of the other tests, showed that while mere visual distraction (reading mentally) caused little embarrassment, the introduction of a lip-motor process caused difficulties, evidenced by oscillations in attention and conflicts in imagery processes. At times B reported that he had succeeded in synchronizing two auditory-vocal-motor processes (one perhaps being ideational and probably purely auditory) and achieved a verbal duet, as it were. The auditory aspect of the two processes differed in intonation.

Attention was enforced usually by concentration on the auditory side of the situation, either the sound of the voice, the sound of the moving pen, or the auditory aspect of the ideational verbal process. Double vocalization sometimes ensued in the effort to hold attention on the writing process; both the word and the letters of the words would be 'auralized,' such images being at times superimposed. Hand-automatism showed itself, evidenced by frequent lapses of the kinæsthetic report and by errors of repetition, incidental to the lagging of attention behind the movement. Only by means of auditory stimulation was it found possible to effect complete distraction. Under such a condition writing became almost thoroughly automatic; it approximated the normal speed; and showed none of the errors resulting from the recall of attention to hand-movement so characteristic of writing under conditions of less perfect distraction. Writing movement under distraction was large and free.

Tested as a guide in an experiment in muscle-reading,[19] B again gave indication of strong tendencies to motor expression. In such experiments, however, in contrast to what has been stated as true in the writing tests, B used visual attention spontaneously, and the voluntary concentration on a vocal-motor process, at the suggestion of the reader, inhibited the motor indications, so far as the 'reader' could judge.

D (the writer).. The usual writing-cue of this observer was auditory-vocal-motor, with pronounced auditory aspect, but at times the control became clearly visual, sensational or ideational according to circumstances. D's control over visual images was, however, inadequate[20] as shown by the difficulties encountered in inverted writing and in writing with

[19] In this muscle reading, the experimenter attempted to find articles hidden by the guide. Indications as to the place of hiding were obtained by touching lightly the wrist of the guide. The time required for the finding of each article was recorded. Variations in the test such as blindfolding the guide as well as the reader were employed. The writer is at present carrying out a series of such experiments as a method of getting at the motor value of different imagery processes.

[20] The perplexity which accompanied such actual inadequacy of the sensory cue (*pace* Professor Woodworth) testifies to the motor ineffectiveness of mere good intentions!

the arm in a strained position, situations in which an anticipatory visual control was attempted. Moreover, the visual images manifested a certain amount of 'automatism' or independence. An inverted 'J' which D had vainly sought to visualize when producing such characters surprised her by its emergence during mirror-writing when its services were no longer required. Again, D was once unexpectedly greeted by a visual report that adopted the characteristic appearance of the hand-writing of another reagent (whose chirography D admired!). This erratic and irresponsible character of visual verbal imagery D reports as also a feature of visual imagery in concrete situations. It should also be noticed that occasionally D obtained a clear-cut visual image of a letter inverted or otherwise transformed which she found herself unable to trace. D reported no hand-kinæsthetic imagery. In general, she finds it all but impossible to imagine a graphomotor image;[21] at best she obtains a serial development of visualized letters, the motor value of which apparently arises from a running of the eye over the contour of each letter. The kinæsthetic report from the hand was, on the contrary, often distressingly acute. The hand was frequently cramped. This report was most evident in the tests of normal writing and in distraction tests when attention went to the writing. Mere distraction, however, served to relieve the hand strain and ranged in its effect from a mere easing of the strain to the production of a complete lapse of kinæsthetic report as to the details of letter formation, a lapse which produced a peculiar sense of irresponsibility.

The distraction experiments heightened mental excitement and usually facilitated writing, partly because the distraction of attention from the hand-movement eased the movement. There was at times a rapid flickering of attention from process to process but on the whole the situation under distraction seemed unified and simply one of such complexity as to demand great concentration of attention. Attention was usually en-

[21] A strong tendency to hand innervation is however evident, for severe muscular fatigue of the hand was on one occasion brought on by a prolonged observation of the writing-movements of other reagents.

forced on a particular process by an intensification of the visual '*report,*' sensational or ideational. Counting, which was almost automatic, did not interfere at all with the vocalizing of the writing-cue, for the vocalization involved little or no throat innervation and was described as vocalization principally because of the feeling of agency accompanying the aural process. Visual distraction caused some difficulty, although visual images were able to float evanescently over a visual perceptual situation with coercion sufficient, however, to keep the writing controlled and conscious. Writing, except in the case of name, was not described as automatic. Sometimes there was a blurring of the visual report with the lapse of the kinæsthetic report, but usually the visual consciousness was intense. In general, under distraction, writing rapidity was increased; there are several tests in which the rate is equal to or greater than any which D was able to achieve otherwise, even when voluntarily speeding. In proportion as the experiment involved concentration, or when attention went to the writing, the writing became diminished in amplitude. In certain tests the writing is very minute. In general, there are few pen-lapses.

S. This subject is in general strongly visual in type, both in concrete and verbal experiences. After some practice in introspection he reported an articulatory verbal process as present during writing, although at first he had been inclined to deny its existence and in certain tests its utility is apparently slight. This articulatory process S reports as purely motor, auditory content having in general but little significance for him. Writing is a well-organized process for S, who has done much clerical work and is an excellent and even penman. The interesting feature in his case was the close fusion of visual and grapho-motor processes, isolation of either being at times impossible. Both visual and kinæsthetic anticipation occurred often in control, particularly in novel situations. Report on the movement made was usually visual, and followed in detail the movement actually made. In general, S was not inclined to be automatic in action and oral-verbal expression was particularly irksome.

The distraction experiments were found difficult; time of writing was retarded. S, however, took them very quietly; attention oscillated deliberately from one process to the other; lapses were comparatively few in number. There was little variation in writing-amplitude.

Tested in muscle-reading, S proved a difficult subject. Very slight motor indications were given. Movements suggested by the reader were repeated over and over again. Under such conditions attention was visual.

Y. This observer reported himself as visual in type; and as also greatly dependent upon articulatory processes. Both statements proved accurately descriptive of his writing-consciousness. The loss of perception of the writing result when Y was blindfolded caused more embarrassment in his than in any other case. There was in this and in other tests a recourse to visual anticipation and visual report. Y's vocal process involved actual innervation varyingly of throat, lips and tongue. Y was doubtful as to its possessing any auditory aspect whatever. There was, moreover, accompanying vocalization, a visualization of the position of the organs involved. This visual-vocal process was thrown into the foreground at times. Curiously enough, in his first attempt at mirror-writing, when questioned as to his control, Y denied the presence of vocalization, explaining its absence on the ground that it would be impossible to reverse the vocal cue. In later mirror-writing tests, however, he used such a cue to inhibit the tendency to concentrate on the seen result, which introduced perplexity. Prior to experiment, Y reported that there was little tendency for his actions to become automatic and that his attention could not diffuse itself over more than one process. Hand-writing in particular demands close attention and is much less automatised than is the lip-motor process.

Distraction experiments of whatever nature caused great embarrassment and were very fatiguing.[22] Attention swung deliberately from one process to the other. There were frequent conflicts of throat and hand processes as though it were

[22] This may have been due in part to Y's physical condition at time of experiment.

impossible to innervate both except in a process already unified; vocalization of capitals, particularly, often introduced difficulties. The time required for writing was very greatly increased by distraction and errors were frequent. The need of attention in order to keep writing controlled was shown in Y's failure to write even his name correctly under conditions of distraction. His writing under such conditions shows disorganization and is somewhat reduced in size.

In the muscle-reading test Y proved to be an excellent subject so long as he made use of verbal consciousness or brought his arm into the field of attention. Mere visual attention on the hidden object was, however, ineffective.

R. This subject showed a dependence chiefly upon hand-motor and auditory-lip-motor control in hand-writing. Visual material was sometimes present and could be evoked by effort but seemed of slight value usually. There was a strong tendency to automatism with emphasis on the motor side of the situation. Motor readjustments, however, were effected with great ease in contrast to the case of H, also motor in control (see report below). The distraction experiments caused excitement and often increased speed of writing. Writing often became automatic but remained well coördinated and shows few errors. Attention operated in other cases by a method of exceedingly rapid flickering; there was little report of synchronization of processes. Writing under distraction became very much enlarged.

R's value as a guide in muscle-reading varied. At times there was a pronounced tendency to follow every movement-suggestion given by the reader.

H. Consciousness for this reagent is strongly motor in content, visual and auditory material being usually conspicuous by their absence. H's writing-cue was frequently anticipatory and grapho-motor, H being confident of the existence of the kinæsthetic image. Although the grapho-motor processes, both anticipatory and 'report,' were those most in evidence, the vocal-motor was also present, letter by letter motivation occurring frequently. This articulatory process is reported to be chiefly motor; H questions its possessing any auditory content

whatever. H reports a high degree of automatism generally; she effects motor readjustments with some difficulty.

In general, H found that the distraction experiments involved little effort, although there was a retarding of the writing and frequent errors. The hand-motor series seemed capable of running itself by way of the kinæsthetic report. Occasionally this report lapsed and automatism resulted. The writing process could be set off reflexly; anything in the situation could be used as initiatory cue.

Tested in muscle-reading, H proved to be a most effective guide. The motor indications were strong and unambiguous. When blindfolded, she lost her bearings and was confused by a shifting of the position of the furniture in the room where the test was carried on, although the situation as a whole was a perfectly familiar one. During this experiment, in order to concentrate on the hidden object, H made use of a verbal process (articulatory).

A. This subject is in general type strongly visual, but has also developed to a high degree vocal-motor automatism. Both characteristics were brought out by the tests. Of all the subjects tested, A used the greatest amount of visual anticipation. Unlike the other subjects who are grouped with him he made little use of visual 'report.' A rarely reported a grapho-motor image and had great difficulty in imaging the writing act in terms other than visual. There was little tendency to lapse of consciousness of writing, although A was the most rapid writer of all those who were tested.

The distraction experiments required effort and writing under such conditions was achieved only by oscillation of attention. The tendency to vocal-motor automatism reduced somewhat the value of counting as a distraction.

F and W. It was, unfortunately, impossible to complete the series of tests on these two subjects. The tests of Part I. show that both, to a very high degree, relied, in writing, upon the grapho-motor sensational series. F, however, adjusted herself to the new conditions with astonishing ease; W, with extraordinary difficulty. Both were excellent guides in the muscle-reading test.

PART I.

1. Blindfolded Writing, Right Hand. Elimination of Sensational Visual Control.

Through blindfolded writing one obtains material for estimating the element of control contributed by actual visual perception of the writing movement and its result. Or, to put it negatively, since writing blindfolded serves to eliminate one of the two sensational control processes it tests (1) the loss incurred by such an elimination and (2) the adequacy of the other sensational control (the grapho-motor) to function alone, or, in certain cases, in conjunction with an ideational visual control.

General statements as to the conditions obtaining in blindfolded writing are met with frequently. Professor Woodworth[1] epitomizes the situation as follows:

"These peculiarities of the muscle sense control may be readily tested by writing with the eyes closed. It will be found (1) that at the ordinary speed of writing, a single letter or a short word can be formed as well with the eyes closed as with them open; (2) that, however, when the speed is low enough to permit of fine secondary adjustments, the eyes assist greatly in forming the letters just right; (3) that extreme slowness is a disadvantage rather than an advantage when the eyes are not used; and (4) that if several words are written with the eyes closed, the alignment is lost or some other constant error makes itself evident."

The statement that in general blindfolded writing tests merely the muscle sense control may be questioned. The elimination of the sensational visual element does not cut out the ideational visual control and in the case of the visualizers the experimental conditions actually throw this factor into relief and emphasize its potency. For a more detailed state-

[1] Woodworth: 'The Accuracy of Voluntary Movement,' p. 72 f. Monograph Supplement to *Psycho. Review,* Vol. 3, No. 13.

ment of the writer's view as to the causal value of the visual material occurring during blindfolded writing the reader is referred back to p. 9. Certain reports bring out specifically interesting facts relative to the relation of the visual image and the kinæsthetic sensation. In other cases, in the effort to obtain an adequate control, there is an emphasis of the other sides of the situation, the auditory, for example.

Spacing and alignment from introspective accounts, as well as on experimental evidence, do appear in great measure dependent upon muscular control based largely on sensational experience; individual differences in this respect testify to the differing adequacy of the kinæsthetic sense. (See table, p. 51.) The movement in changing from one line to another is not, it should be noticed, merely a repetition of the movement from left to right. It is an attempt to reproduce the extent of this left-right movement in centripetal terms. Moreover, qualitatively the two movements are very different, since the first includes the kinæsthetic effort involved in the arm-hand-finger movement required in the formation of letters, while the second is a free sweep of the arm from the end of one line to the beginning of the next. In the present test since before writing blindfolded the observer had written the verse several times with eyes open, he might have been expected to possess a more or less accurate motor image of the extent of the movement required in passing from the end of each line to the next. However, the changes in word-spacing introduced such variation as to make the spatial judgment a novel one.[2]

Relative to the kinds of errors students of blindfolded writing have recorded, reference may be made to Crépieux-Jamin's observation[3] of a constant tendency for writing to begin in successive lines farther and farther to the right. (An observation not confirmed in the case of every subject of the present test, although found to be generally true.) Crépieux-Jamin also testifies to the accuracy with which letters and details of punctuation are taken care of. He raises cursorily the ques-

[2] For an experimental demonstration of the nature of such a judgment of movement-extent, see Woodworth, *op. cit.*, p. 7 f.

[3] *L'écriture et Le caractère*, p. 152.

tion as to the amplitude of writing under blindfolded conditions. He is puzzled by the approximation to normal size, because of his expectation that the withdrawal of light—a dynamogenic factor—would result in a decrease in the writing amplitude. His explanation for the failure of such expectation is that the dynamogenic effect of the effort involved in writing thus more than compensates for the loss of light.

Preyer[4] comments on the similarity of writing produced when blindfolded to that written with eyes open, citing as the only differences (1) that words and lines are separated more than the normal extent, due to the writer's anxiety to keep them from running one into the other and (2) the fewer breaks in the continuity of the writing, attributed to the writer's fear of losing his position if he raise his pen.

The results obtained in the present test will be discussed chiefly in connection with the nature of writing control. The tabulated results on pp. 50 and 51 give in figures the rapidity of blindfolded writing, the general area covered, the errors in horizontal alignment, and the errors of line displacement from the vertical. These figures have no absolute value, for the measurements are taken from only one test. (Others were, however, tried and the results are similar in character.) But taken with the other figures given, these measurements indicate certain individual peculiarities. The normal given is that taken on the day of the blindfolded test.

The introspective studies are made from two (or three) trials in writing verse and name blindfolded, compared with reports on a normal taken the same day. In general the tests confirmed the slight dependence, in writing, upon visual perception except as directive in the matter of spacing and alignment. In contrast to the general result, one observer (Y) found that writing blindfolded involved great effort. The embarrassment caused by the absence of perceptual visual control was evidenced by many mistakes in the writing, such as repetition of letters and letter-parts, disorganization in formation of letters and great increase in the time required for writing. The writing-cue of this observer was definitely visual and

[4] *Psychologie des Schreibens,* p. 34 f.

anticipatory. To a less extent the same difficulty was evident for another observer (A) who also reported visual anticipation as his control.

A summary follows of the principal control processes used.

1. *Vocal-motor Control.*—The vocal-motor verbal process, with or without audition, depending upon the observer, was reported by all as present. The verbal unit was usually the word, but with line-unit for one (A) and letter-unit for another (S). Y also made use of letter vocalization after the word was initiated visually; vocalization of capital letters interfered, however, with the writing of them. Letter-vocalization with emphasis on the auditory aspect was also resorted to by B at moments of hesitation. The vocal accompaniment was less prominent when the name was written. It was reported unmistakably by only two observers (R and F); a third (D) made use of a suppressed mental mumble and occasional vocalization.

2. *Auditory control* in the form of a report from the sound of the pen was mentioned by only one observer (B).

3. *Visual* material was at a minimum in the case of three observers. Two reported none except for name (H and F); a third, visual anticipation of only one word, of the spelling of which she was doubtful, and occasional visual report (R). B, who has little verbal imagery in visual terms, except an occasional anticipation and visual report, visualized vividly the concrete aspects of the situation and got visual space values, probably in dependence upon tactile values. The writing of the first word in the verse is often, however, initiated for this observer by a visual cue.

Much visual material was reported by the other four observers. For D the process takes the form of a vivid visual report which is cited as affording moral support. Although this report is not felt to be essential, D is unable to suppress it. There is no visual report as to the appearance of the whole. Normally the report is in her own hand-writing but on at least one occasion it appeared in the hand-writing of another, a hand-writing D was unable to reproduce. Visual control was essential to the other three observers (Y, A, S).

For the first, anticipatory visual verbal imagery served as a cue; this was supplemented at times of hesitation by a visual report. A also made use of visual anticipation but was unable to get space values visually. S used a certain amount of visual anticipation, letter by letter, with a great deal of visual report which was utilized in dotting i's, crossing t's, etc. He reported visualization of the whole situation, both verbal and concrete, and mentioned the interesting fact that the amount of visual verbal report visible at any one moment depended upon the position of the visualized hand and pen, so that moving the hand from the end of one to the beginning of another line increased the amount of writing that could be seen.

It was mentioned in a preceding paragraph that vocal control was less noticeable for name than for verse; visual material, on the other hand, was increased in amount. Every observer mentioned it in the form either of anticipation or report, and either for whole or part. The question arises whether this report of increased visual material may not be due to the fact that such material, being evanescent, escapes the memory and so is not reported at the close of a longer writing-sequence. Or it is possible that the autograph, being as it were one's verbal photograph and social representative, acquires thereby a heightened visual significance.[5]

4. *Grapho-motor Control.*—That motor control is utilized in writing blindfolded is of course evident. Introspective testimony to the presence of this factor was, however, infrequent. Most observers were conscious of utilizing motor and tactile sensations in spacing or, at least, in realizing space-values and in estimating the extent of movement necessary in making the sweep from the end of one line to the beginning of the next; one observer spoke of the eye-strain involved in lining.

An attempt was made to have the subject reproduce with eyes open certain words of which he had had a visual report when writing blindfolded, with the object of testing the ade-

[5] For an interesting treatment of graphology as applied sociology, see article by Tarde, 'La Graphologie,' *Revue Philosophique,* XLIV., p. 337.

quacy of this report as a translation of the grapho-motor series. In the case of the name, a pronounced size illusion appeared for D[6] and R. Capitals, particularly, were reproduced in characters much larger than the originals. A slight illusion of the same nature appeared also in the reproduction of the first verse-word (B).

A curious relation between the visual and motor situation was reported by Y, in that movement towards the beginning of the line in returning to the left was checked by the visualized edge of the paper. Y was distressed by the shortening of the movement this image effected. The same observer remarked, relative to an error in crossing a capital 'T' as though it were an 'F,' that the 'T' was reported visually as correct, although the motor report testified (and accurately) to the presence of the cross-piece; in the second test in connection with the same letter, Y, aware of an intention to cross the 'T,' was not aware that he had done so; but in witness to the embarrassment of the situation was the persistence of the visualized 'T' throughout the writing of the rest of the line. B also cited a case in which the visual report announced a letter as complete, although the motor report felt inadequate. As a matter of fact the letter was telescoped.

The loss of visual perceptual guidance is evidenced by wide spacing of lines and words, of which several observers were aware, but used as a resort to avoid running words into one another; by defective alignment, both horizontal and vertical; and in one case by degeneration in the formation of letters. For a numerical statement of errors see the table on p. 51. In summary, it may be said briefly that the error in horizontal alignment is for four observers a fall from the initial level; for three others the error varies from one of ascent to one of descent; for the remaining observer the error is uniformly a slant up—although this subject reported that the lines ran downhill. Progressive displacement of lines farther and farther to the right (under-estimate of extent) was evident in

[6] The amount of this illusion, D has since discovered, varies with variation in direction of attention. It is greatest when attention is focused on the forearm movement; least when attention is focused on the finger movement or the visual report.

the writing of four subjects; for two others the displacement was to the left; and for the remaining two it varied in direction. This error of progressive displacement is evident even in normal writing and in the case of one subject (D) persists in spite of an endeavor to correct it.

The amplitude of the writing was considerably increased for Y, and slightly for R, H and S.

Blindfolded writing was used also in connection with left-hand writing, mirror-writing and 'speeded' writing; it was also used in connection with certain distractions. The results obtained from these different experiments should be compared. Compare also Plate I., Nos. 1 and 3.

2. Left-Hand Writing. Embarrassment of Grapho-Motor Control.

As the object of the test was to get a statement of variation in the sensory control in adults when the customary grapho-motor coördination is embarrassed, no discussion of spontaneous left-hand writing is called for. One trial each in writing the given verse, the phrase, and name was made (1) with eyes open, (2) with eyes closed. (Cf. also left-hand mirror-writing.)

As might be anticipated the verbal unit actually functioning as grapho-motor cue is, in the case of left-hand writing, more fragmentary than in the case of right-hand writing. In the case of at least four observers the actual cue came one letter at a time.

1. *Vocalization Process.*—The utility of this process ranged from the one instance in which apparently it was the only motivation to hand-movement (R), to its marginal presence. The observer reporting the articulatory process as the only cue, used it letter by letter. The fact that writing blindfolded she was able to do the verse in 67.8s., less than half the time required by every other reagent, taken in connection with the illegibility of the letters, which were scarcely formed at all, tends to substantiate her introspection. In another case, that of H, writing was preceded by a grapho-motor cue and also accompanied by letter by letter vocalization. For other reagents word by word

vocalization accompanied writing with occasional recourse to spelling.

2. *Visual Material.* (*a*) *Perceptual.*—The value of the visual perception of result in controlling movement was very evident in writing with the left hand. It was no longer a case of the eyes being used merely as an aid in alignment and spacing; they were directly instrumental in controlling the formation of letters. The least utilization of visual perception was shown by R. Introspectively she reported but slight dependence upon vision; writing, whether eyes were open or closed, was motivated by the spelling out of the words. The increase in legibility and coördination with the use of the eyes, although not as pronounced as in the case of the other subjects, testifies, however, to a certain amount of visual control. As before, the rapidity of this subject is in excess of that of the others. F made so little use of visual report that only after writing some time was she aware that she was not doing it mirror-fashion.

(*b*) *Ideational.*—This control was particularly noticeable in the blindfolded writing, but occurred also in anticipation in writing with eyes open. Three observers motivated left-hand writing mainly by the visual cue. There was a double visual series, both anticipatory and sequent to writing, the two visual series not always being in agreement. A reported, moreover, an actual fatiguing of the eyes by the writing, in contrast to the hand and arm fatigue mentioned by other observers. He noticed a strain of the eyes toward the right, particularly in writing the last two lines of the verse, lines which were unusually long. This strain of eyes at the periphery is noticeable in ordinary writing by A, who wears glasses. The interesting point, however, is the fact that he had difficulty in visualizing the words at the outer edge of the sheet. The writing at this place is badly disorganized. Such disorganization is, it is true, found in the writing of every observer, for movement at this point becomes difficult on account of the cramping of the forearm as it is drawn in toward the body. Further interest attaches, however, to the visual embarrassment. Was it a translation of the motor difficulty? Y motivated his writing by

visual anticipation, letter by letter, following a vocalization of the word. This visualization is reported at times as a visualizing of the required right-hand movement and includes a picture of the hand as well as of writing. This process is the obverse of that noticed by Y in blindfolded writing, right hand, where visualization of the word was followed by letter by letter vocalization. The change in control is evidently due to the break-up of the motor habit. S reported a visual anticipation, letter by letter, each seen as though made by the right hand (S utilized as copy the hand-writing of a penman whose chirography he had often imitated). This visualization of letters was accompanied by a grapho-motor image (with perhaps hand innervation) of the letter as made by the right hand, a motor image then translated into left-hand terms. S cites also a visual report which he judged, in case of blindfolded writing, functioned as an important part of the cue. The other observers report visual ideational control in varying degree; none for R and F; slight visual report, H; letter by letter visual report, B; strong visual report, D.

3. *Grapho-motor Control.*—In four reports there is introspective evidence of dependence upon grapho-motor anticipation as cue to the movement. S, as given above, used grapho-motor anticipation in connection with visual cue, translating the right-hand movement into a left-hand movement letter by letter. H likewise cited a motor feeling anticipatory to the making of each letter; this plus the letter-articulation constituted her cue. F was preoccupied with the motor side of the situation and was inclined to believe that there were anticipatory grapho-motor images. The clearest-cut case of conscious grapho-motor control is found in the blindfolded writing of B. Motor images were used as cue throughout. These anticipations ran ahead of the writing by two or three letters. Writing with eyes open, however, B reported less grapho-motor anticipation, for the visual report, used here to check up results, introduced a certain amount of conflict between report and movement, and the auditory cue became accordingly more pronounced.

The visual-motor conflict just mentioned is reported also by

another observer, Y, for whom the visual anticipation of right-hand writing issued in a movement lacking the expected ease; this conflict threw into prominence the kinæsthetic report from the hand.

The object in beginning with a blindfolded test of left-hand writing was partly the hope of chancing upon a case of spontaneous mirror-writing; therefore no directions were given as to the edge of the paper at which to begin writing. Only two subjects showed any hesitation. H debated at which margin to begin, but finally decided in favor of the left. F tried at first beginning at the left, then at the right, then at the left again, and finally at the writer's suggestion (given indirectly) wrote from right to left through the first line, then began again at the left. It was not until she had finished the verse (left-right) that she became aware by an inference that the line as written first was reversed in appearance. The right-left movement she considered a much easier movement than the left-right. During the writing of the verse there were frequent reversions to such a movement.

D showed some tendency to mirror-writing; a tendency which had to be inhibited in both blindfolded and eyes-open test; in both cases the visual checking of the grapho-motor impulse was quite evident. The illusion of size reported for this observer (blindfolded writing, right hand) was pronounced in writing with left hand, eyes closed; the visual report gave a doubling of actual size. The return to conventional form of letters was also noticeable, an evidence of increase in amount of visual control. See Plate III, 6 (*a*), 6 (*b*).

For specimens of left-hand writing, see Plate I, Nos. 2, 4, 4(*a*) and 4 (*b*).

3. A. Mirror-Writing. Right and Left Hand. Embarrassment of Visual and Grapho-Motor Control.

Mirror-writing was introduced into the present series of experiments with no intention of testing the various hypotheses cited in explanation of spontaneous mirror-writing. It was employed solely as a device for investigating the individual

variations relative to the sort of control that would be utilized in mirror-writing induced voluntarily.

In such a connection it is obvious that only experimental reports on voluntary mirror-writing are pertinent to the present discussion. The questions whether or not spontaneous mirror-writing be a pathological occurrence; whether or not it be the normal writing for the left hand of all persons, or the normal left-hand writing for the left-handed only, need not be entered upon. Further, hypotheses that explain mirror-writing through a theory of 'cross education' or through the greater ease of centrifugal or abductive movements, or find an explanation for it in the child's attempt to copy, identically, with the left hand the seen movements of the teacher's right hand, will be considered only incidentally in connection with the results of the present experiment.[7]

It should, however, be noticed that, in general, writers on the subject agree that mirror-writing is the more apt to result, the more the visual factor falls into the background, whether this occurs because of mental blindness or because of the impairment of attention, habitual or momentary. Mirror-writing is particularly likely to occur if such inattention carry with it an ignoring of the requirement that writing should be visually significant. It is quite in accord with such a conclusion that the slight tendency to spontaneous mirror-writing that was noticed in the present series of experiments occurred in just those subjects in whom visual control, perceptual and ideational, was, in general, least in evidence.

A detailed account of experimental work on voluntary mirror-writing may be found in the article by Abt, cited in the foregoing footnote. Reference to this article, so far as it deals with voluntary mirror-writing, will be made freely and the conclusions there published will be compared with those reached as a result of the present investigation.[8]

In the present experimentation on mirror-writing four tests

[7] See, particularly, Weber: 'Spiegelschrift,' *Ztsch. f. klin. Med.*, XXVII., p. 260 (1895); Wegener: 'Die Spiegelschrift,' *Ztsch. f. Päd. Psychol.*, I., p. 254 (1899); Laprade: 'Contributions à l'étude de l'écriture en miroir' (These Med., 1902); Abt: 'L'écriture en miroir,' *Année Psychol.*, VIII., p. 221 (1901).

[8] See also Laprade, *loc. cit.*, p. 45 f.

each were tried on writing verse and name: viz., mirror-writing, left and right hand, the reagent being blindfolded; and the same test with left and right hand when the reagent had his eyes open. Preceding these experiments there was a blindfold test with the left hand, with no instructions given for direction of writing, in the hope of chancing upon one or more cases of spontaneous mirror-writing. In this preliminary test, only two subjects (H and F) showed the least hesitancy as to direction of movement. Abt accounts for the relative infrequency of spontaneous mirror-writing, left hand, by the fact that visual representation accompanies the writing and consequently under all conditions writing remains under visual control. As has already been stated, conditions favored mirror-writing in the case of the two reagents just mentioned, both of whom made little use of visual material.

In the present series the first test on mirror-writing was made with the eyes closed in order to ascertain the adequacy of the visual cue, if it occurred, and the distinctness of the visual 'report,' if any, in comparison with the perception of the result of the movement when the eyes were open. No directions were given to the subject other than instructions to write from right to left. Several subjects were wholly unacquainted with the nature of mirror-writing and the tests upon them afforded excellent material for estimating the accuracy with which motor sensations were translated into visual terms; two of the observers (H and D) were somewhat practised in mirror-writing. In any case, habituation to the movement was very rapid.

As in the case of left-hand writing (Test 2) the articulatory process was pronounced only for certain observers. B reported distinct vocalization, evident particularly in blindfolded writing with the left hand (first test), in which test there was subdued vocalization of each word with superimposed spelling out of the longer words. R also reported vocalization throughout and spelling out of the longer words. F used, in the first test, vocalization letter by letter; and, in the later tests, word by word vocalization, insisting that the vocal was her only cue. The other subjects were preoccupied with vis-

ual or motor material; articulation if present was marginal. Abt's subjects, on the other hand, in general reported letter by letter enunciation preceding the tracing of isolated letters, each of which was the object of a special act of attention, the word having lost its unity.

Relative to the sort of control utilized by his subjects Abt grouped them in three classes:[9] (1) those who before writing represented the form of letters in mirror-writing; (2) those who were dependent upon a visual representation of the symmetrical movement; (3) those for whom, apparently, the auditory-motor image immediately evoked the movement. The validity of the control cited by the third group Abt questions, being inclined to attribute such a report to faulty analysis; for, he asks, if the auditory motor image calls forth left-hand mirror-writing, how can it call forth by the same mechanism right-hand mirror-writing?

The types of actual control, Abt thus reduces to two, both of which are visual. For the voluntary mirror-writer, according to his explanation, is in the position of a child learning to write. The first condition of such an achievement is to have a visual representation of the appropriate movement which, he adds, is the only precise notion we can have of a movement —a statement open to question. A visual image of the reversed letter may, however, take the place of the visual representation of the required movement and such a substitution gives us the type of control of group (1), to which only three of Abt's thirty subjects conformed. This method of initiating mirror-writing was found to be a slow and laborious one. The writer was apt to become confused and there was frequent reversion to normal writing, either for the whole or a part of a letter. Dependence upon visual representation of the symmetrical movement was the usual method of control. The mistakes of those using such control, unlike those of group (1), were rarely errors of reversion to normal writing and never of partial reversion of a letter; the mistakes that occurred were due to the letter by letter method and included omission or doubling of letters. In general, Abt holds that the more diffi-

[9] *Loc. cit.*, p. 228 f.

culty a subject has in abstracting from his visual imagery, the more difficulty he has with mirror-writing.[10]

Of the eight observers tested in the present series only one (A) used an anticipatory image of reversed letters, converting the visual into a motor image with a little visualizing of the hand in movement and of the moving pen-point. A second observer (S) used visual anticipation after the first test but apparently received initiation into the required movement through motor processes. For the first writer the production of mirror-script was a labored process and there were frequent failures to reverse either the whole or a part of a letter. On the whole the reports from this observer would throw him into Abt's first group.

The writer questions, however, the possibility of classing all the other observers under the second description given by Abt, where visual representation of the required movement served as cue. For why may there not be a motor as well as a visual representation of a movement? In the cases under consideration a visual representation of the movement was rarely spoken of, but grapho-motor control was frequently insisted upon, sometimes as a matter of anticipatory imagery. Certain facts to be mentioned later, together with results from other tests, in which writing is modified, led the writer to accept the possibility of a purely motor representation of the movement.

To cite again particular cases. Three observers (F, H and R) reported scarcely any visual material in the nature of an anticipation, or, when blindfolded, of a report. F who wrote rapidly and with ease insisted (cf. Abt's third group) that the vocalization of the letters served as sufficient cue to the writing and that no visual control whatever entered into the process. Throughout tests requiring inversion or reversal of writing she initiated the process with a conscious intention (perhaps put verbally) of moving the hand in a certain direction. After the writing was once initiated the habit-

[10] *Loc. cit.*, p. 224. Cf. Baldwin: *Mental Development*, p. 99 f., and Goldscheider: 'Physiologie u. Pathologie der Handschrift,' *Archiv f. Psychiatrie*, XXIV., 2, p. 503.

ual motor automatism was adequate, and there was very little anticipation of any sort. R had a slight visual report from blindfolded writing but depended largely upon motor automatism, writing in the first test rapidly and with the same slurring of details noticed above in her left-hand writing from left to right. H also reported motor control and her slight dependence in general upon visual consciousness would confirm her report.

It is interesting to note that the mirror-writing of the last two observers mentioned shows the error of incomplete reversal of letters, cited by Abt as found only in the writing of those initiating the process by a visual anticipation of the reversed letters. On the face of it, indeed, one does not see why breaks of such a kind should not result from a rapid automatic as well as a slow visual reversal.[11]

B reported anticipatory motor cues with no consciousness of reversal except of the general direction of movement and in the case of a few perplexing letters. Occasionally B made the letter in the air normally and then reversed the movement. Writing was accompanied by a visual report. Once a capital letter, an initial of his name, was anticipated, visually in one style and 'motorly' in another, B finally yielding to the motor anticipation. Such a conflict shows the relative independence of visual and motor control. Y also used motor control and his writing was accompanied by a visual report, which he found distressing since it gave a peculiar feeling of mental reversal. The movement itself was easy. As to the adequacy, in the last case, of the visual report from the movement, it may be mentioned that although Y had a distinct enough report on each letter serially, so that he was able to reproduce his name as it had appeared to him when writing blindfolded, the appearance of the whole was surprising and novel.

[11] D had practised mirror-writing so frequently that her report can scarcely be compared with those of the other subjects. If her memory be correct, however, she learned mirror-writing by writing on a blackboard with right and left hand simultaneously, fastening attention on the visual report of the right hand. Such a method, according to Abt, is valuable only for those who belong to his first group.

S reported for the first test an anticipatory right-hand motor cue which was reversed and so converted into a left-hand mirror-writing cue. This motor cue, judging from other tests upon S, may well have been a visual representation of the required movement although he did not so describe it. The interesting feature of this particular case is that after the first test, in which control was spoken of as motor and in which the writing of each letter was followed by a visual report of its appearance, S began to utilize as anticipatory cues the store of images furnished by the movements reported in such terms. In all tests after the first he had an anticipatory visual image of each letter reversed and also a visual report of the letters as written, the latter extending often several letters back.

In general, writing with the eyes open gave results somewhat better coördinated than the blindfolded writing. Alignment and spacing were improved. Only one subject (Y) complained that the presence perceptually of the result of movement was troublesome, and he succeeded finally in ignoring the tracery by concentrating on the vocalization of the verse.

Abt's discussion includes some interesting observations relative to the comparative characteristics of right-hand and left-hand mirror-writing. Right-hand mirror-writing, he observes, is steady and calligraphic, but lacks the appearance of a running hand. There are frequent breaks between letters, the strokes are short and the letters end abruptly. It is retouched frequently and is vertical or slants from right to left in contrast to the slant of normal right-hand writing. Left-hand writing is hesitant with slender wavering strokes, has blunt angles and is elongated and pointed. Its connections, however, are made with ease, it is a more rapid hand than right mirror-writing and has more of the characteristics of the running hand, although it does not resemble the normal right-hand writing.

The samples of mirror-writing obtained in the present test follow the above description only in the case of certain individuals. The description covers excellently the characteristic differences of the writing of the two hands in the case of A and R. Running writing appeared for the right hand in several of the other observers. Interestingly enough the ob-

server most practiced (D) wrote a running hand in both cases; the two hands resemble one another closely and are like the ordinary left-right tracings of the left hand.

Another distinction between left-hand and right-hand mirror-writing, given by Abt, relates to errors in alignment. Left-hand mirror-writing is found to ascend, as is normal right-hand writing, both movements being similar in so far as they are, relative to the body, centrifugal movements. On the other hand, right-hand mirror-writing, together with left-hand unreversed writing, descends, both movements being centripetal. These statements were by no means uniformly true for the subjects under discussion, as is evident from an examination of Table III. given below, in which the error in alignment is given for right and left hand in both the centrifugal and the centripetal movements, eyes open and closed. The individual characteristics are interesting, as is also the exceeding accuracy of the alignment, vertical as well as horizontal, shown in certain cases of mirror-writing.

Left-hand mirror-writing has often been cited as an evidence of cross-education or transference of practice-effects to symmetrical parts of the body. It is so considered by Davis,[12] as well as by others before him. It is not clear in this connection why insistence should be laid upon the ability of the left hand to write reversely while its ability to write from left to right is ignored. The former, it is true, is held to result from the writer's surrender to motor sensations which in such cases are dissolved from the 'optical percept' (Davis is citing Goldscheider[12]) and is the more readily achieved the less the writer is under the influence of the 'optical percept.' The seeming implication of such a conclusion is that left-hand unreversed writing remains under the direction of the visual percept or image and that the transferred motor education, if there be such, must be symmetrical.

Abt, in rejecting the hypothesis of cross education, interpreted as meaning the education of a cortical center through the development of a symmetrical center, rehearses as adverse facts

[12] Davis: 'Researches in Cross-Education,' *Studies from the Yale Psychol. Lab.*, 1896–98, Vol. VI., p. 6.

the following:[13] (1) simultaneous right-hand writing facilitates left-hand mirror-writing only when the subject belongs to his (Abt's) first type, control visual; (2) when the two hands write together the movements are successive rather than simultaneous; (3) left-hand mirror-writing is symmetrical to the usual right-hand writing in no exact sense; they are unlike in appearance; (4) the right hand also acquires mirror-writing with great readiness. All of these facts contribute to Abt's conclusion that a visual representation of the required movement comes into clear consciousness in mirror-writing and is directive. A pure motor image is impossible.

So far as the present experiments bear upon the point in controversy, they tend to show that in the case of any particular observer there is a tendency for similar motivation for left-hand writing, both centripetal and centrifugal, although it is true that grapho-motor control has with certain subjects acquired in mirror-writing a value not reported in unreversed writing. It is not merely a question of visual control for the identical and of motor control for the symmetrical movement. In opposition to Abt the possibility of a purely grapho-motor control, either sensational or ideational, is maintained. And it appears from Table II., which gives the time-readings for the various tests, that, so far as rapidity of adjustment to the conditions is concerned, a grapho-motor control is more effective than a visual control. But in opposition to the theory of cross education it is urged that such a grapho-motor control is evident in left-hand unreversed as well as in left-hand mirror-writing and also in the *right-hand mirror-writing*.

Summary.—In accord with the literature of the subject a tendency to spontaneous mirror-writing was most evident in those subjects who made least use of visual control. When, however, the reagent started out with the conscious intention of writing mirror script with either right or left hand, visual anticipation of the letter-form, or visual representation of the movement required, were possible methods of initiating the movement. The present test shows in addition the possibility of grapho-motor anticipation and suggests also the possibility

[13] *Loc. cit.*, p. 250 f.

of a grapho-motor automatism which can function in the reverse. (Cf. Test 4.)

With the exception of one subject (H) grapho-motor control, anticipatory or automatic, was, so far as rapidity is concerned, more effective than visual anticipation. With reagents so initiating movement there is, however, a greater dependence upon a vocal-motor cue than is found in the case of the other subjects. Practice effects mask the possible variation in rapidity, due to the shift from left to right hand or from closed to open eyes. In general, the right hand acquired mirror-writing as readily as did the left. (Compare Plate I., Nos. 1, 5, 6, 7, 8, 7*a* and 8*a*.)

3. B. Reading Mirror-Writing.

Reading mirror-writing involves the utilization of many complex mental habits. It is a much more complicated affair for most people than is mirror-writing. The records on spontaneous and pathological cases of mirror-writing show that the writers are unable to translate their productions unless this habit be deliberately acquired. That is to say, facility in writing mirror-fashion does not carry with it ability to get meaning visually from such script. This fact is, indeed, urged against attempts to explain pathological and spontaneous mirror-writing as due to visual difficulties, presentative or representative. The test was introduced in the present series with the hope of establishing some relation between the imagery processes used in the reading and writing of reversed script, and particularly to determine whether motor tracery would be utilized in the attempt to interpret such visual signs.

Method.—The script used in the reading test was prepared by the experimenter. The same sentence was submitted to nine reagents and the time and method required for its interpretation recorded. A second sentence, similar in character and containing the same number of letters, was prepared for the experimenter, D. The sentences chosen were of such a nature that the context was somewhat difficult to get.

Result.—The greatest individual difference found was the extent to which the context was utilized. Certain reagents

(B, A, F), given a few letters, were able to construct the meaning of the whole. Others (W, D, and especially H) received little help from the meaning of the sentence.

Again, great differences were evident relative to the range of variation within which certain letters, or even words, were recognized through their similarity to normal script. For all observers certain letters were visually significant even in their reversed form; but the number of letters so recognizable varied greatly from individual to individual. For R many words were recognizable as wholes at the first glance.

Visual reversal of letters was attempted by most reagents, but unsuccessfully. B, however, utilized a backhanded visual reversal, as it were; for the reversed letters would suggest a normal letter which would then be reversed and compared with the given letter. This reagent, with the exception of R, made the best record at the test. In general, visual material was utilized very unequally by different reagents. A letter or word once recognized assumed a fixed value only for certain subjects; others repeated the original process of interpretation.

There was less recourse than the writer had expected to tracing the letters in the effort to interpret them. Such utilization of motor material would perhaps have been greater if each subject had been engaged in deciphering his own handwriting, although mirror-writing does not bear the marked individual stamp of ordinary chirography. H, who found the test extraordinarily difficult and who failed to get any meaning from the sentence as a whole, is strongly graphomotor and attempted to use motor tracery in translation of the writing but gave up the attempt because the writing was so unlike her own that it offered no point of contact. D also attempted to recognize letters by tracing them, but was unable to do so although strongly motor in writing mirror script. Occasional use of motor material was made by B, W and H; but the value of the method was, on the whole, insignificant.[14]

[14] Some of Abt's subjects resorted to motor tracery in deciphering mirror-writing (*loc. cit.*, p. 238 f.). Abt, however, holds that this reading was not through the mediation of the movement sensations, but rather through the visual representation of the movement of the hand. The method was more successful when the tracing was actually done on paper, a mode of tracing not attempted by the subjects in the test above.

Habitual methods of apperceiving certain symbols often introduced difficulties in interpretation. A similarity suggesting a false interpretation would cause more disturbance than a symbol that at first bore no similarity mark and was worked out with effort. The word 'at,' which reversed resembles a 'to,' caused great trouble. For S 'h' reversed was persistently read as 'd'—which it is in German script. H and Y were unable to apperceive a reversed 'f' as anything but 'J,' although the letter occurred in the word 'of' and the context was unmistakable; by means of the context Y finally succeeded in supplying the letter, but H completely failed to do so.

The time taken by the different subjects in reading the mirror script follows. The time-readings are not wholly comparable, for Y and H wrote down letters as soon as recognized and thus had a slight advantage, visually, over the other subjects who read the words aloud.

Subjects.	Time required to read sentence in mirror-script.
R.	40s.
B.	1 minute, 14s.
F.	1 minute, 35s.
A.	3 minutes, 10s.
W.	7 minutes, 30s.
S.	9 minutes.
Y.	9 minutes.
D.	16 minutes, 51s.
H.	Over 25 minutes.

Conclusion—In general, the test had little bearing on the topic under consideration other than showing that the greater mental readiness and facility in adaptation shown by certain subjects in the more distinctly motor tests is parelleled by the result from this test, which is sensory in nature. If the time-readings given above be compared with those in Tables I. and II., it will be seen that there has been little shifting in the relative position of the nine subjects, if they are ranked according to the quickness with which they adjusted themselves to the test-conditions.

4. Inverted Writing, Right-Hand. Embarrassment of Visual and Grapho-Motor Control.

A variant on mirror-writing was introduced by a test in which the subjects were asked to invert writing, that is, to write upside down. The subject was allowed to follow his own preference in beginning at the left or the right margin of the paper. Those most dependent in this test upon visual anticipation in every case but one choose to begin at the right edge. A simple visual inversion was more readily 'imageable' than a reversed inversion; and in fact by a mental *tour de force* certain observers were able at times to see the result of this upside down movement as upright. In general, there was a gain of visual over grapho-motor control, if this test be compared with that of right-hand mirror-writing. The test, on the whole, was more difficult than mirror-writing, although individual differences were more pronounced than in the preceding test. A glance at the time-readings given in Table I. (p. 50) shows at once the relative ease with which any particular observer achieved success in the undertaking, although the fact that the writers did not all begin at the same edge of the paper and write in the same direction makes intercomparison somewhat less valuable. The variation in rapidity is great in any case, ranging from less than *five* to over *twenty-two* minutes. The difficulties experienced by particular observers in this test are comparable with those observed in the succeeding one. (See p. 43 f.)

F, who did the writing in the record-time (4m. 27s.), inverted writing with ease, using either hand and beginning indifferently at either right or left margin, although the left-right writing took 44s. longer than that running from right to left and was, F reported, a trifle more difficult, since if she became 'mixed' in the movement, it was more difficult to reëstablish it because of its greater likeness to normal movement. F reported also word by word vocalization but no visual material of any sort. She started writing simply with a definite intention of reversing up and down directions. Errors were reported in kinæsthetic terms and were usually corrected. F wrote the words as wholes, and when she became confused and

baffled in the process, she would cross out the word as a whole and begin it anew. The writing was a running hand. (Plate II., 1.)

R, whose time is only a trifle longer than F's (5m. 9s.), wrote from right to left and produced a much finer copy than did F with no corrections. In appearance the writing is similar to R's right-hand mirror-writing and is a round, vertical, well-formed hand. The first two words were initiated by visual anticipation of letters afterwards inverted, but after R had once caught the required movement, visualization was resorted to only occasionally.

A similar appearance is presented by the inverted writing of B, who, unlike the subject just named, wrote from left to right. For this subject a visual cue was necessary in order to get a word going; after the word was started, movement-reversal was sufficient. The letters visualized were seen originally above the paper, and were then turned over on the paper and traced. There was some tendency in the last line for B to see the writing reported as upright.

Y, writing from right to left, combined visual and motor control. Y was unable to make the required movement until he had formed a picture of the letters. Many letters were visualized upright and then turned over, but Y found it very difficult to visualize details. He did not, moreover, trace the visualized letters. In the case of one letter he was able to see it inverted correctly, without being able to copy it. At several places there was a tendency to see the writing upright. The writing is well-formed and running.

S also wrote from left to right an even running back-hand script, using visual anticipation for every letter; a letter was first seen upright, then inverted and finally reversed and the image actually projected on the paper. After a letter had been made once, no further visualization was required; the grapho-motor cue was sufficient. When asked to write his name from right to left, S found the process much easier than that used in writing the verse, simple inversion being sufficient. The report from this test should be compared with that of the observer when doing mirror-writing. In the latter

case practice effected a shift from grapho-motor to visual control; in the present test there was a tendency for the visual to yield to the motor. (Plate II., 2.)

The five observers just mentioned produced good copy with few errors; the four remaining subjects were less successful and the writing of one (W) is undecipherable.

A used visual anticipation; some letters were visualized originally as turned over; some as upright and afterwards inverted. Closing the eyes increased vividness of imagery. The writing shows frequent failures to invert.

D found the test one of very great difficulty. She was unable to form a motor idea of the required movement and her visual imagery was inadequate. She attempted visualizing letters upright and then inverting them but was unable to effect the inversion. She also attempted to invert the seen movement of the hand used in tracing letters in the air. This method was ineffectual. Finally D succeeded partially by imaging words on paper right side up and then tracing them deliberately from the other side of the line.[15] This involved a splitting of attention, so to speak, the tendency throughout being to see the writing as normal. This effort of attention was accompanied by a twist of the head to the side and over the writing. This writing runs from right to left and required frequently the inhibition of a mirror-writing tendency. There are, moreover, frequent errors of reversion to mirror-writing. Inverted writing from left to right was, however, for D 'unimageable.' (See below for account of development of habit of inverted writing.)

H wrote from left to right and used grapho-motor control, a reversal of the normal motor cue. The process was a laborious one and there were words not inverted. H spoke of the difficulty of keeping her place in writing and in two cases there are word-substitutions.

[15] Relative to the dependence of such work upon the manner of apperceiving the situation may be mentioned the case of a girl, whom the writer tested, who labored painfully over the production of inverted writing (right-left), until she discovered that the writer—who sat opposite to her—could see the characters upright. She exclaimed, "I'll see them from your side of the table," and began to write rapidly.

W found the experiment almost impossible. Although he declined to begin at the right edge of the paper he frequently made the letters from right to left. The collection is literally one of letters and is a motley array of upright, inverted, and reversed inverted letters. W used no anticipatory visual cues but thought that at times he made use of the perceptual visual process in correction. He often made movements in the air and then tried to reverse them. The difficulty of the process he judged to lie in the inhibition of old writing-habits. (Plate II., 3. Compare Plate I., Nos. 1 and 9, and Plate II., 1 and 2.)

5. Writing in Strained Positions of Arm and with Variation in Direction of Movement.

In this test the reagent wrote his name in several abnormal positions of hand and arm, the direction of writing, left-right, up-down, etc., also being varied. The positions assumed were those required in writing on a tablet placed upon the forehead,[16] on top of the head, parallel to, or at right angles with, the back, or over either right or left shoulder. Not every combination of writing-direction and position was tried with each observer.

An introspective account of writing-cue and report under such conditions of writing was asked for and, as a check on such an account, the subject was asked to reproduce, in normal position, the results obtained in writing under the test conditions. The results are highly characteristic of the different observers and test the adequacy with which the writing control of any particular reagent is able to function under new conditions. The cues here utilized are, largely, visual and grapho-motor. The immediate reaction of the several observers to experimental directions, which were given simply in terms of place and direction of writing, indicated at once control tendencies, for whereas the visualizers were ready at once with questions as to the point of view from which the writing was to be read, those more motor in control accepted the directions as sufficient. The reproductions vary from observer to observer. There is, for

[16] See Wegener: 'Ueber recht-u. rückläufige Stirnschrift,' *Ztsch. f. Psychol. u. Physiol. der Sinnesorgane,* XVI., p. 190.

example, reproduction of the visual anticipation, in which, since the reagent mentally assumed a position that would enable him so to view it, the writing is normal in appearance throughout the series; there is reproduction of visual report in which movement is translated into visual terms in such a way that the appearance of the writing varies, with position of the arm, from normal to mirror or inverted writing; there is reproduction on the basis of a purely kinæsthetic report, a reproduction that, visually, resembles the preceding type but is differently conditioned.

The individual reports in this series are given as meriting particular attention. The results should be compared with those obtained from the same observer in the case of inverted writing. In any one case there will be found the same ease or embarrassment in the manipulation of motor or visual control.

B utilized visual and motor material in both anticipation and report. There was also an auditory-vocal-motor accompaniment which was felt to be a non-essential element. The visual control of the situation was complete. B was able, for instance, to see the result of writing as it would appear if the tablet were transferred from the given position to the writing-table, the whole transfer being in concrete visual terms; or he was able to see the writing as it appeared in the given position viewed from any particular point in the situation. In executing movements some interesting adjustments occurred. For example, when writing from left to right on top of the head B found the anticipated arm-movement impossible and there was a visual and kinæsthetic shrinking of the whole situation; the initial capital shrank from an inch and a half to half an inch in height. Again, in writing on the forehead, down-up, there was a kinæsthetic conflict, apparently ideational, between tensions in the arm at this level and when resting on table.

D showed a general dependence on visual control, but the control was inadequate. D found herself at times unable to place the visual image in the desired position preparatory to tracing it. Visual and kinæsthetic report were also inadequate, so that in reproduction of the result, D frequently had recourse to memory of the visual cue. In the simpler experiments where

the tablet was placed over left shoulder (writing right-left) or tablet placed at back (writing right-left, pencil toward body) there was no visual cue, except perhaps for the first letter; accompanying the movement, however, there was a fairly adequate visual report, reproduced without difficulty. With the transfer of tablet to vertical plane on forehead (writing up-down) a visual cue, letter by letter, appeared. The difficulty was extreme. D was unable to begin movement until 'J' was projected on paper in desired position. Before D succeeded in getting an upright 'J' it was seen in inverted mirror-writing, perhaps in fusion with kinæsthetic image of the same. At the final letter, a 'y,' there was a conflict between visual and kinæsthetic control with final surrender to the kinæsthetic, which proved to be wrong. The reproduction was on the basis of neither visual nor kinæsthetic report, the first not having been present and the second having escaped memory; it was simply a repetition of visual anticipation. When the tablet was placed flat on the face and D instructed to write down-up, she found herself greatly embarrassed. It was found impossible to get the visual cue in position for running movement and finally the hand was allowed to engineer itself, which it did with some success. The visual report was very distinct, but D was unable to reproduce it. In the next test, in which tablet was placed parallel with back (writing right-left, pencil pointing from body), D again yielded to motor control and was unable to retain visual report long enough to reproduce it. This motor control is not anticipatory and D has no sense of agency in connection with it; it is accepted as a last resort. In the next test, in which tablet was again parallel to back, D found herself unable to visualize situation, but decided to attempt mirror-writing, since directions were to write left-right. The result was a most peculiar conflict between kinæsthetic sensations and visual report. There seemed to be an actual split in the process, that is, the visual images and grapho-motor sensations were reporting a double, not a single act.

S The reports from this observer are of particular value as affording illustration of most intimate fusion of motor and visual imagery. S reported anticipatory visual cues which,

however, under the conditions holding in certain of the tests, appeared, not in normal, but in reverse or mirror-writing. The writer is inclined to think that such reversal of the visual cue (?) was due to anticipatory motor imagery, or, possibly, innervation, so that the visual translation of the motor anticipation actually ran ahead of the writing. S, however, was not inclined to accept such an explanation, for the visual image did not seem to him dependent on motor anticipation. One particular test furnished a variation of control which the writer interprets as confirming her position. S was writing from right to left with the tablet placed on the top of his head; the visual cue, letter by letter, was seen in reverse, S looking at it as if from below. Suddenly, the last syllable of his name, 'land,' appeared as a whole in normal writing on the tablet which apparently had shifted to a vertical position on the forehead and was looked at as if from the front. The change seemed due to report of strain from kinæsthetic sensations and with the visual shift the movement was eased. This means, according to the writer's interpretation, that up to the point of transfer, the visual material represented a pseudo-control only; but with the embarrassment of the motor situation it became actually directive. S's reproductions were usually on the basis of the kinæsthetic report and consequently, as the conditions varied, changed from normal to mirror-writing.

Y This observer, like the preceding one, had anticipatory visual images of letters in reverse. These images, however, in the more strained positions of the arm were reduced in value and were reported as dependent upon anticipatory grapho-motor cues. Occasionally Y found himself unable to visualize letters before his arm was placed in position and at times he allowed his hand to do the work without anticipatory control of any sort. Besides visual cues, he also had visual reports, the two at times not agreeing. In one instance Y stated that cue and report were seen from different positions; the cue was seen from the side, the report from in front, an angular difference of 90°.

A The control for this observer was undoubtedly visual anticipation. A questioned the experimenter in detail as to point of view from which writing was to be seen. In every

case he assumed mentally a position from which writing could be seen as normal, although in the first trial (writing on forehead right-left), there was at the start a tendency to visualize mirror-writing perhaps in fusion with anticipated movement, a tendency checked by A's transferring himself to a position in front of writing. Every reproduction is in normal left-right writing with very little attempt to reproduce irregularities of movement. There was not a scrap of articulatory accompaniment to writing. The usual method involved the tracing of the already visualized signature projected in the required position. The projection was not always easy for A. Up-down writing on forehead was motivated by visual imagery that seemed fluid and unconvincing; and in the down-up writing in same situation A visualized first from the left and found the movement impossible, then from the right with motor success. On writing on top of head, front-back, a marked movement-illusion appeared, an error in direction equivalent to 90°. A reported that the writing was seen as though he were looking down upon it from the left and that he found it very difficult to visualize from this position. (See below, where this illusion is discussed in connection with other reports.) In this particular case the question arises as to the relation between the visual embarrassment and the motor error. Since, after the first letter, A resorted to a right-left signature in the usual plane, it is possible that the visual difficulty with subsequent visual shift caused the error.

R A surrender to motor automatism was here evident, anticipation of any sort being infrequent although R occasionally spoke of motor cues. There was little visual imagery except in the simpler tests of writing on forehead, right-left and left-right; in the first case slight visual anticipation, and in the second, a little visual report. Hand and arm once placed in position the movement followed automatically. There was little detailed kinæsthetic report; at most, R spoke of certain movements as being easier than others and once or twice she reported herself unable to reproduce exact movement. Throughout the test she was unaware of any reversal of movement, so that all reproductions are in normal writing. It may

be stated that R's results, from the standpoint of legibility and coördination, are among the best obtained.

H In the case of this reagent, again there was complete absence of visual material. Control was grapho-motor; at times anticipatory. Reproductions were on the basis of kinæsthetic result. The variations from the preceding report are given, as being interesting. Writing on tablet placed on forehead both left-right and right-left was reproduced in mirror-writing. H was puzzled by the fact that the movement-report for both signatures should be similar although the hand had moved in different directions. She was unable to put the situation in its visual terms. The third time of writing name on forehead right-left, she observed that she would write so that writing could be read from in front. This writing was done with great painstaking and consciousness of movement and at least three letters were written left-right instead of right-left. The reproduction of this, from the kinæsthetic report, resulted again, to H's great surprise, in mirror-writing. The reproduction was detailed even to the reversal of the three letters mentioned above. H was unable to see that the change in position of the tablet from forehead to table explained the result visually. Again, reproduction of the signature on top of head back-front gave normal writing, but not until H saw her own reproduction of motor report was she aware of what the visual appearance was.

F This observer gave results in certain respects unlike those of any other reagent. She followed directions unhesitatingly; the process was automatic with anticipatory motor cue for general direction of movement and occasional motor cue and report at difficult places. In attempting reproduction of result, she had neither visual cue nor visual report to guide her, nor did she attempt a reproduction of motor experience. By an exceedingly rapid process of inference, carried on mentally in motor terms, with perhaps a faint visualizing of hands in process of movement, she transferred the tablet from the given position to the writing-table, in such a way as to discern the lay the signature must have on the paper, if she were to reproduce the appearance of the original in the given position. The

result is that, visually, the reproductions copy, in appearance and general direction, the originals when transferred to the writing-table, and are unlike the reproductions of other observers.

W The control for this reagent was grapho-motor but he reported a tremendous break in the coördination, a break which was evident in the outcome. To reproduce the movement at all, W was often obliged to repeat the movements in the air, reproducing the autograph usually in sections. He resorted to such a method even in the reproduction of left-right writing on the forehead and was surprised at seeing the normal signature which resulted.

In writing front-back with tablet placed on top of head, an error of 90° in direction of movement was reported for A, under the same conditions an error of 45° in direction occurred in the writing of H and S. The reverse occurred in the case of Y; although there was no error in the actual direction of writing, he reported, on the basis of the motor sensations, that such an error in direction of movement had occurred.

In conclusion, to make the comparison of individual results the easier, Table I. is appended giving a statement of the appearance of the name when reproduced, a statement followed by a phrase showing the method used in reproduction. The simpler tests of writing left-right and right-left with tablet placed on the forehead are chosen as sufficiently characteristic. It should be recalled that the writing from left to right on the forehead, although requiring no change in movement, appears, when the tablet is transferred to the table, in mirror script. On the other hand, right-left writing, although requiring a reversion of movement, when written and transferred to table, appears normal. The reproduction of signature will differ depending upon the method employed. Visual anticipation, visual report and grapho-motor report may all be utilized in reproducing the writing.

For purposes of further comparison, in the fifth column of the table is given the time required by each reagent to write the test-verse in inverted characters, followed by a statement of the principal control used.

TABLE I.

Reagent.	Reproduction of Writing on Forehead.			Inverted Writing.	
	Direction of Writing.		Method Used.	Time.	Writing Control.
	Left-right.	Right-left.			
B.		Normal	Visual transfer to table	6m. 25s.	Visual and grapho-motor anticipation.
D.	Normal	Mirror	Visual report	11m. 58s.[17]	Tracery in inverse of upright characters.
S.	Normal	Mirror	Grapho-motor report	7m. 22s.	Visual anticipation, requiring both inversion and reversion.
Y.	Normal	Mirror	Visual report	9m. 2s.	Visual anticipation.
A.	Normal	Normal	Visual anticipation	9m.	Visual anticipation.
R.	Normal	Normal	Grapho-motor automatism	5m. 9s.	Automatic inversion.
H.	Mirror	Mirror	Grapho-motor report	8m. 45s.[17]	Grapho-motor inversion.
F.	Mirror	Normal	Motor transfer to table	4m. 27s.	Automatic inversion.
W.	Normal		Grapho-motor report	22m. 13s.[17]	Grapho-motor inversion.

TABLE II.

RAPIDITY:[18] VERSE.

Eyes.	Right Hand.						Left Hand.			
	Normal.		Mirror Writing.		Speeded.		Normal.		Mirror Writing.	
	Open.	Closed.	Open.	Closed.	Open.	Closed.	Open.	Closed.	Open.	Closed.
B.	75	82	176(3)[19]				180	200	184(2)	202(1)
D.	75	83.2	194(4)	128(2)	59.8	49.6	199	155	209(3)	199(1)
S.	72	81	260(3)	229(2)			230	203	250(4)	297(1)
Y.	78.5	90.5	304(4)	406(2)			240	261	255(3)	540(1)
A.	57.2	69	274(3)	385(2)	38.8	43.4	180	187	360(1)	
R.	74	75	176(3)	210(2)	55.4	53.8	143	67.8		137(1)
H.	85.4	80.4	324(3)	386(2)	52.2	49.2	240	203		334(1)
F.	61	77	176(2)	171(3)	56.4	60	185.4	279	164(4)	192(1)

6. Tables II. and III. give in tabulated form the rapidity with which the test-verse was written in the blindfolded, left-

[17] These reagents report a lack of what is known as 'sense of direction.' An inquiry into the functioning of imagery processes at moments when directions of movements are confused would probably yield interesting results. The above test, with that described in 5, is capable of much greater elaboration than was made of it in the test cited. Cf. Binet's 'Illusions of Reverse Orientation,' *Psychol. Rev.*, I.

[18] The readings are given in seconds.

[19] The numbers in parentheses give the place of the particular test in the mirror-writing series.

hand, and mirror-writing tests, with measurements for the area covered in writing the verse under the above conditions together with errors in alignment.

TABLE III.

MEASUREMENT OF AREA COVERED IN WRITING VERSE, WITH ERRORS IN ALIGNMENT.

See note for key.

Eyes.	Right Hand.						Left Hand.			
	Normal.		Mirror Writing.		Speeded.		Normal.		Mirror Writing.	
	Open.	Closed.	Open.	Closed.	Open.	Closed.	Open.	Closed.	Open.	Closed.
B.	144x65[20] 4 A[21]	140x135 28 D	190x80 8 A				170x76 3.8 A	168x156 18 D(2) 8 A(4)	190x95 4 A(4) 2 D(2)	230x180 22 D(4) 10 A(1)
	1–V[22]	3.4 L	2.2 L				3 R	6 V	2 L	15 V
D.	162x63[20] 5 A[21]	180x110 5 D	156x66 2 A(3) 2 D(1)	170x166 40 D	204x76 2 A	204x115 12 A	172x76 6 D	218x160 23 A(4) 20 D(1)	206x65 5 A(2) 2 D(2)	230x160+ 62 D
	3 R[22]	9 R	1 R	9 V	4 R	25 V	1.2 R	7 V	5 L	4 V
S.	149x56[20] 4 D[21]	189x113 30 D	120x50 3 A	130x124 7 A(3) 5 D(1)			118x50 5 A	132x95 9 A(5) 2 D(1)		216x127 17 D
	.6 R[22]	12 R	1 L	17 V			1 R	8 V		17 V
Y.	116x76[20] 1.3 D(4)[21] 3 A(1)[22]	200x210 14 D	196x75 2 D(3) 6 A(2)	210x132 8 A(5) 2 D(1)			174x85 4 A(3) 2 D(2)	222x170 15 D	200x93 10 A	240x160 78 D
	1–V	10 R	2 V	7 V			3 R	9 V	5 L	17 V
A.	140x78[20] 2 D[21]	218x124 12 D(3) 9 A(2)	169x106 3 D	172x121 29 A	154x96 1.4 A	156x92 5 A(2) 1 D(2)	42 A(5)	168x134 42 A(5) 5 D(3)	185x73 4 A(5) 3 D(1)	
	1 L[22]	10 V	1 L	4 R	4 V	6 V		13 V	2.4 L	
R.	177x84[20] 2 D[21] 5 V[22]	196x110 25 A 7 R	184x100 10 D 2 V	176x164 15 D 4 V	204x94 .7 V 2 V	218x149 26 D 11 R	180x112 17 D 6 V	198x170 176 D 17 V		222x116 9 A(3) 2 D(2) 6 R
H.	154x53[20]	199x150	195x93	Measurement impossible.	181x56	230x185	202x78	225x151		250x155
	3 A[21]	7 A(3) 31 D(3)	5 D(3)	32 A(3) 20 D(3)	4 A	16 D(4) 10 A(1)	2 A(4) 2 D(2)	13 A(4) 9 D(2)		Irregularity too great to measure.
	.6 R[22]	2.3 L	2 L	7 V	2 V	6 R	2 R	8 V		
F.	182x90[20] 8 A[21]	226x116 9 D(3) 4 A(2)	194x95 4 A(3) 6 D(1)	198x102 12 A	220x96 7 A	230x170 18 A 20 D(1)	187x87 4 D 3 A(2)	260x140 15 D	157x88 17 A	245x144 33 A
	.8 V[22]	13 V	4 L	12 V	2 R	7 V	2 V	9 V	2.3 L	5 V

7. *Conclusion.*—The results obtained from the different tests are, in the case of any one individual, strictly comparable. The main individual variation was the extent to which the subject had recourse to grapho-motor control, either conscious

[20] Whole area covered in writing verse; measurement in mm.

[21] Error in horizontal alignment; average of six lines, measurement in degrees; A = ascending, D = descending.

[22] Error in displacement of lines; measurement in mm.; L = left, R = right, V = variable. Average from five lines.

or automatic. Such a control was the normal one for F, R, H and B. A, D, Y and S, on the other hand, were more dependent upon visual material. Variation occurred within the groups as given. Grapho-motor control was more conscious for B and H than for R and F. In the second group, the visual control was for A, anticipatory; for D, a control in terms of visual 'report.' Y and S frequently reported a visual control that assumed both anticipatory and report forms. Y and S also reported at times conscious anticipatory grapho-motor images, a report which rarely occurred in the case of A and D.

The conditions under which writing went on influenced somewhat the nature of the control utilized. Writing blindfolded caused little alteration in the normal control for members of the first group, whose writing is organized chiefly on a grapho-motor basis. Under like conditions, members of the second group reported much visual material and in at least one instance, the loss of visual perception caused degeneration in the appearance of the writing.

In left-hand writing the characteristics of the two groups remained unaltered except that for the first group grapho-motor anticipation was more frequently reported than before. Such anticipation in ideational terms was particularly noticeable in the case of B.

Mirror-writing increased the tendency to rely on a grapho-motor control, a surrender partly to motor automatism but partly also a control by motor anticipation. Members of the second group (S and Y) made more use than before of grapho-motor control. A alone depended wholly upon visual anticipation.

In inverted writing, in contrast to mirror-writing, there was a gain of visual over motor control. This was evident particularly in the case of B and R, members of the first group. Cases occur as before of surrender to motor automatism and such a method of control was the most effective, if rapidity in writing be used as a standard. Extraordinary difficulty in inverted writing was found in the case of D, H and W. This difficulty seemed independent of the nature of the control

utilized and was paralleled by the difficulty the same reagents experienced when attempting to translate mirror-writing.

Writing under a strained position of the arm and in various directions gave the same individual results as the other tests. Great differences were found in the ease with which different reagents were able to orient their movements in these experiments, in their ability mentally to shift their position in space without confusion. B and F gave greatest evidence of ease in spatial adjustment; the first had recourse to visual, the second to kinæsthetic imagery. D, H and W were spatially confused by the tests.

The results of the tests raise the question of a motor automatism which can function although the direction of movement is altered. Such automatic reversal and inversion of direction of writing was evident particularly in the case of F. Other reagents, who found an initial cue necessary, were able to proceed with the word or line with ease when once the movement was initiated. Emphasis is laid upon this point because it raises the question involved in 'cross education' in a different way, for it is equally evident in the case of the right- and of the left-hand movements. Again, it bears perhaps some relation to the general question of orientation. H, W and D, who found movement reversal particularly difficult to achieve, also report frequent difficulties in general bodily orientation.[23]

[23] D, after the experiment in inverted writing described above, practised the feat for some time. Skill in visualizing inverted writing came rather speedily, although at date of writing it remains still impossible for her to visualize first upright and then invert. Skill in writing inverted characters (from right to left) came slowly and developed only to a slight extent. With such development in skill, however, just the condition reported by F was noticed. If the first letter of a word was once successfully initiated by a visual cue, the movement-reversal of the rest of the word ensued automatically.

A pretty confirmation of this conclusion occurred September 19. Up to this time inverted writing from left to right had been for D a 'sealed book' owing to the absolute impossibility of her visualizing such writing. The day in question, however, she conceived the plan of writing the first word of the test-verse right side up and then inverting and turning over the paper upon which the word was written and tracing the word in transparency in the hope of continuing spontaneously with the next word of the verse. In spite of visual bankruptcy and utter failure to ideate such a movement 'motorly,' D succeeded in continuing the movement thus initiated. Such a method involved automatic inversion and reversion, that is, a turning over of the control of movement to an old habit which functions in a novel direction.

PART II.

Analysis of Writing Control by Means of Distraction.

1. Statement of Method.

Distraction[1] as an experimental method has been used in various connections. It has been shown to be of dubious value if used in the hope of getting quantitative statements as to the attributes of attentional states. For (1) distraction is usually partial and discontinuous, and interstitial flashes of attention are often sufficient to direct the process from which attention is supposedly abstracted; and (2) any given process has a very different distracting value for different individuals, depending in part upon the general mental value of the distraction process itself, and also in part upon the subject's method of handling the double process in terms of imagery or of attention-functioning. But an individual's method of response to any particular distraction is in itself significant, and while the search for a method of complete distraction bids fair to continue for some time, yet the search has already yielded valuable information relative to imagery and attention types. It was with such a purpose that it was used in the tests, the results of which are given below.

Specifically, the distraction experiments served several ends. Any particular distraction either (1) introduced conflict of imagery and so threw a particular control process into the foreground; or (2) caused a 'shunting' of the control and so tested the various possible 'controls' of the subject tested; or

[1] For a critical examination of distraction methods see Alice J. Hamlin, *Amer. Jour. of Psychol.*, Vol. VIII., pp. 1–66.

Distraction has been used in investigation of 'Muscular Memory,' T. L. Smith, *Amer. Jour. of Psychol.*, Vol. VII., pp. 453–490; to test the possibility of 'Visual Reading,' Secor, *Amer. Jour. of Psychol.*, XI., pp. 225–236; to discover the nature of the modification of one psychological process by the coincident presence of a second, Binet, 'Concurrence des États Psychologiques,' *Revue Phil.*, XXIX., pp. 138–155; to discover characteristics of 'Normal Motor Automatism,' L. M. Solomons and G. Stein, *Psychol. Rev.*, Vol. 3, pp. 492–512; to produce lapses to be utilized as material for an experimental study, Bawden, 'A Study of Lapses,' *Psychol. Rev.*, Monograph Supplement, Vol. 3, No. 14.

(3) issued in actual distraction of attention from writing for a longer or shorter interval, so that writing approached automatism.

In order to test the possibilities of control in the case of any particular reagent it should be noticed that complete distraction of attention is by no means necessary. Conflict of processes with consequent oscillation of attention is quite as instructive; for such conflict throws into relief and permits description of the disturbed process. Again, the possible objection that the particular 'control' utilized in any test is an outcome of the experimental conditions and in no way tests the control process in ordinary writing may be met by pointing out the uniformity in the results from any chosen reagent in spite of the variation in experimental conditions. Or, put negatively, the different distractions make evident the processes that are not possible 'controls' for the subject tested. In the case of a subject for whom there are several possibilities of control, the 'shunting' of the control as conditions change is highly instructive. Those reagents who achieved a synchronization of different processes carrying different meanings furnish interesting material for a study of the mode of functioning of attention and the nature of the meaning consciousness, as well as giving valuable information relative to the specific imagery processes involved.

The following distractions were used: I, counting aloud (auditory-articulatory distraction); II, reading mentally (visual distraction); III, reading aloud (visual, auditory and articulatory distraction); IV, counting aloud, blindfolded (auditory-articulatory distraction with visual perceptual control eliminated); V, counting mentally the number of times a particular word occurred in a rhyming list that the experimenter read aloud (auditory distraction). In these tests as in those of Part I, the subject wrote the verse there cited, his own name, and the phrase 'University of Chicago.'

The experimenter in all tests timed the writing during distraction; the normal time of writing, with which that of the distraction test is compared, having been obtained before the distraction test began. In the case of every method of dis-

traction, the experimenter could estimate the rapidity and accuracy with which the distracting operation was carried out. In the case of test II (mental reading as a distraction), the reagent was required to point out the last word read and to identify, very shortly after the test (at most a few seconds) the list of words read. For this purpose the list was slipped at random among a number of lists similar in appearance and to a certain extent identical in wording. When reading constituted the distracting process, lists of unrelated words were used so that the process would not be facilitated by context.

Immediately at the close of each test the subject volunteered an introspective report, which the experimenter recorded. The experimenter also questioned the subject, asking practically the same questions of each subject. Particularly was the reagent questioned as to whether he was aware of any error in writing, and, if so, how he was conscious of it. His report in this case could be checked by the actual result. In the case of all distractions but those of V, the test was repeated three times, unless omitted through accident or unavoidable interruption. In the first test in each series, attention was undirected so far as instructions given by the experimenter were concerned; in the second test of the series, attention was thrown on the distracting process; in the third test, attention was thrown upon writing. Practice and fatigue effects fell upon the same place in every series, but to a certain extent the preliminary experiment, attention undirected, allowed the subject to 'warm up.'

Before a discussion of the results is attempted, the experimental records for the tests upon the verse are given in full with a table that shows the comparative results from the different subjects. For the tests on the name, results are tabulated separately for each subject with a verbal summary of result. In addition to the facts recorded for the verse, in the case of the name, measurements in mm. were taken of the writing amplitude.

2. Individual Reports of Distraction Experiments. Writing of Verse.

SUBJECT B.

(Average time of writing verse, perfectly memorized, for eight trials, 65.5s; mean variation, 4.15s.)

I. Counting Aloud and Writing. Eyes Open.

(Normal time of writing for day, February 26, 69.8s. Normal rapidity of counting, 130 in 60s. One trial each for writing and counting.)

A. *Attention Undirected.*

One trial.

(*a*) Experiment difficult but amusing. Oscillation of attention evident. Conflict noticeable between counting-articulation and vocalization of words written. There was a feeling of strain in arm as though movements were being made with the left hand; also a keen consciousness of tactile and kinæsthetic sensations.

(*b*) Writing-cue was auditory-vocal-motor. Visual and hand-kinæsthetic cue occurred rarely.

(*c*) Time required for writing, 130.8s. Number counted, 120. Lapses: three words are blurred in consequence of correction of some indistinguishable error.

B. *Attention on Counting.*

One trial.

(*a*) Oscillation of attention with conflict of vocal-motor processes. Attention was enforced on counting by throwing it on the sound of the voice and the throat tensions. B was conscious of the hand when writing coördination went adrift. Visual perceptual process was used in correction of errors, although B thought that, on the whole, the test would be easier if the eyes were not focused on the writing.

(*b*) Writing-cue was auditory-vocal-motor; there was little automatism.

(*c*) Time required for writing, 138.4s. Number counted, 130. Lapses: several corrections were made in writing but it is impossible to determine the character of the errors.

C. *Attention on Writing.*

One trial.

(*a*) B counted in a very low voice, in one place inaudibly. Attention was not strongly focused on writing. In the writing of the first three lines there was some fluctuation of attention; with the fourth line the auditory aspect of the writing-cue emerged clearly and from this point on there was little conflict. The counting at this point became automatic.

(*b*) The writing-cue was auditory-vocal-motor, with strong auditory aspect from third line on.

(*c*) Time required for writing, 117.5s. Number counted, 107. Lapses: three, corrected.

Summary.—The writing-cue (cf. cue for name under same conditions, Table VI.) was auditory-motor vocalization, a process which conflicted with the counting. The perception of the result visually was not felt to be of much assistance, although it was utilized in the correction of errors. Attention was enforced on counting by focusing on auditory and throat sensations; on writing, by focusing auditory aspect of the vocal cue. The decrease in conflict as the auditory aspect of the writing-cue became pronounced was evidenced both introspectively and by the lowering of the time-readings. Under all conditions of attention there was a great increase in the time taken to write verse. The increase was greatest when attention was on the counting; least when on the writing.

II. Reading Mentally and Writing.

(Normal time of writing for day, March 6, 65.4s.)

A. *Attention Undirected.*

One trial.

(*a*) Some fluctuation of attention. When acute, attention was on the reading. There was, however, little strain; the experiment was interesting and exciting. There was loss of the feeling of strain in hand experienced in normal writing and the hand moved more rapidly than B had anticipated. B was, however, conscious of tactile sensations and the hand was felt to be covering more than the normal extent of space. Many of the words read, when reviewed, aroused no sense of familiarity.

(*b*) The writing-cue was auditory-vocal-motor, the auditory aspect being pronounced. In this way the writing-cue was distinguished from the vocal-motor reading process. The verse came by lines and phrases. No visual material was noticed in writing, except visual report for sign '&' which was then changed to word 'and.'

(*c*) Time required for writing, 61.2s. Number of words read, 39. Lapses: 4; substitution of word ('April' for 'leap-year'), 1; repetition of letter ('t,' written first as a capital, repeated as small letter), 1; omission of letter-parts ('u' and 'x'), 2.

B. *Attention on Reading.*

One trial.

(*a*) Writing more nearly automatic than in any preceding test, although there was some slight awareness of tactile and kinæsthetic report from hand. Attention was not intensely concentrated on reading. Although words were read in groups they did not convey much meaning. An auditory-vocal-motor process accompanied reading but dropped out at moments of greatest concentration.

(*b*) There was no distinct consciousness of any writing-cues, unless, perhaps, an auditory cue at the beginning of lines.

(*c*) Time required for writing, 61.7s. Number of words read, 86. Lapses: 3; repetition of letter-parts ('n'), 2; omission of letter-part ('m'), 1. Many of the letters are badly formed.

C. *Attention on Writing.*

One trial.

(*a*) Auditory-vocal-motor reading process which was synchronous with the auditory-vocal-motor writing-process, resulting in a 'verbal duet' in which the verse-words were intoned in a sing-song fashion and the words read given a circumflex intonation. The attention was enforced on writing by a doubling of the auditory-vocal-motor writing process (both lines and words separately were vocalized), and by concentration on the auditory report (scratch of pen) and concentration on the tactile report.

(*b*) The writing-cue was auditory-vocal-motor for first two lines before the writing or reading began, followed by same process for each word. The same method was used throughout verse.

(*c*) Time required for writing, 64.3s. Number of words read, 26. Lapses: 1; substitution of word ('February' substituted for 'leap-year').

Summary.—The comparative time-readings of I and II show that visual distraction introduced much less conflict than did articulatory. Although vocalization accompanied both reading and writing, B apparently achieved a synchronization of the two vocalization or auditory processes. The doubling of the auditory-vocal-motor process as writing-cue when attention was concentrated on writing should also be noticed. Under all conditions of attention the time-readings are below the normal for the day. The low time-reading, the great number of words read and the introspective report all point to a condition approaching automatism in the writing of verse, while attention was concentrated on the reading.

III. Reading Aloud and Writing.

(Normal time of writing for day, March 12, 66.8s.)

A. *Attention Undirected.*

Two trials.

(*a*) First trial. B broke down just after starting second line in the *middle* of the word '*the.*' He could give no report as to what had taken place; he did not know what he had written.

Second trial. The experiment was found to be difficult but exciting, becoming easier toward close. There was evident a conflict of the auditory-vocal-motor processes which accompanied both writing and reading. There was a persistent tendency to write the words and letters which were being read.

(*b*) First trial. No report of any writing-cue. Second trial. The writing-

cue was an auditory-vocal-motor process, although possibly this process was in the nature of a report rather than a cue. The report from writing was, in general, in terms of kinæsthetic sensations from arm and hand and auditory sensations from the scratching of the pen. This report, however, lapsed as soon as attention went to the reading.

(*c*) Time required for writing: first trial, no report; second trial, 104s. Number of words read: first trial, no report; second trial, 32. Lapses: first trial, 2; repetition of letters ('hass' for 'has,' 'Septembeber' for 'September'). Second trial, 8; repetitions of syllables, letters, or letter-parts, 4; omissions of letter and letter-part, 2; anticipation of letter, 1 ('Steptember' written for 'September' with tendency in the next line to repeat 'September' in place of 'November.' B wrote 'Se' and then crossed it out and went on with correct word); coalescence of word read with letter seen, 1 (word 'done' was written preceding the word 'days,' probably an auditory combination from 'd' and word 'tongue' which was being read or seen). B reported that he was aware of the errors at the moment of making them but lost memory of them immediately. There was no way of testing the truth of his report.

B. *Attention on Reading.*

One trial.

(*a*) Attention not on reading throughout. Most of the reading was done in the breaks between the lines of writing. The hand moved easily when the vowels in the words written and read were the same.

(*b*) The writing-cue was auditory-vocal-motor; this cue was not, however, required for all the words written.

(*c*) Time required for writing, 146.2s. Number of words read, 82. Lapses: 14; intrusion of word-parts from reading list, 3 ('Thak tharty' written for 'Thirty'—the word read was 'bank'; 'Jufe' written for 'June'—word read was 'life'; 'fgh' written for 'fine'—word read was either 'eight' or 'night'); omissions of letters in whole or part, 4; repetition of syllables or letter-parts, 6; repetition of word, 1; reversion in fourth line of verse to wording of verse learned originally.

C. *Attention on Writing.*

One trial.

(*a*) This test was much easier than the preceding. Attention was, however, not strongly concentrated on writing. There was little tendency to write the words read.

(*b*) The writing-cue was an auditory-vocal-motor process, with an emphasis of the auditory aspect, which marks it off from the writing-cue of the preceding test.

(*c*) Time required for writing, 75s. Number of words read, 26. Lapses: 7; omissions, 3 (two letters and one word); repetition of letters, 2; insertion of letter, 1; in writing the word 'June,' part of the 'u' was omitted and in attempting to straighten out the kinæsthetic report B. doubled the 'e.'

Summary.—A comparison of the results of III and II indicates that the introduction of overt articulation increased the difficulty of the test and raised the time-readings, a result com-

parable with that obtained in I. The corresponding series (A, B, C) in I and III are closely comparable. Attention upon the articulatory process, probably equivalent to auditory distraction, retards the writing; whereas attention upon the writing, through auditory enforcement, facilitates it. The number correspondence in words read in II and III (A, B, C) should be noticed.

The loss of the visual perceptual series in III is shown by the large number of lapses, in contrast to the result in I. Again, the attentional value of articulation is shown, in contrast to II, by the character of the lapses in III.

IV. COUNTING ALOUD AND WRITING. BLINDFOLDED.
(Normal time for day, March 19, 62s.)

A. *Attention Undirected.*[2]

One trial.

(*a*) Some oscillation of attention. After a word or phrase was started, it was allowed to run itself. The general mood was one of relaxation. There was a strong kinæsthetic report from the hand, which was reassuring; and, also, a blurred visual report which was disconcerting. The auditory report from the pen-scratch was also evident. B. was aware of errors but not in detail.

(*b*) The writing-cue was auditory-vocal-motor. At the beginning of one line the sweep of the arm from the close of the preceding line was felt to constitute the cue.

(*c*) Time required for writing, 94s. Number counted, 72. Lapses: 10; omission of letters or letter-parts, 3; repetition of letters or letter-parts, 6; doubtful error, 1.

B. *Attention on Counting.*

One trial.

(*a*) B counted in a low voice; attention was not intensely concentrated on counting. There was some kinæsthetic, some visual report from writing; in the first line there was a lapse of all report with accompanying uncertainty as to result.

(*b*) The writing-cue was auditory-vocal-motor, with more cues utilized than in the preceding test.

[2] This test was repeated May 21; and again May 28. The results closely parallel those of March 19. Time, May 21, 94s; May 28, 80s. Number counted, May 21, 71; May 28, 73. Lapses, May 21, 13, viz., omissions of letters or letter-parts, 7; repetition of words or letters, 6. May 28, 6, viz., repetitions, 3; exhange, 1; substitution, 2. In both tests some auditory-vocal-motor control was used, but there was much automatism. B reported that the lapses were due to the return of attention to writing and that a more perfect distraction would reduce errors.

(*c*) Time required for writing, 109s. Number counted, 123. Lapses: 14; repetition of letters and letter-parts, 8; omission of letter and letter-parts, 3; transposition of letter-part, 1; errors of substitution or anticipation, 4.

C. *Attention on Writing.*

One trial.

(*a*) Counting went smoothly while attention was on writing. Toward the close of the test attention was diffused. As a matter of fact over a third of the counting was done during the writing of the first line of verse.

(*b*) The writing-cue was auditory-vocal-motor, word by word. By the time B reached the middle of a word there was a lapse, or perhaps retardation of the kinæsthetic report, so that he was uncertain as to what he had written. This difficulty caused errors.

(*c*) Time required for writing, 112s. Number counted, 87. Lapses: 12; repetition of word- and letter-parts, 7; omission of letters and letter-parts, 3; transposition of letter-part, 1; repetition of substituted letter, 1.

Summary.—The writing-cue, which was auditory-vocal-motor, occurred less frequently in this series than heretofore. As compared with I, there was evident a growing automatism with reference to the writing-sequence. This result is probably evidenced by the lowering of the time-readings in IV as compared with I, although the absence in the latter case of visual distraction may also be influential. The large number of lapses was probably due to the fact that although writing tended to become automatic, attention returned to it at places and so introduced errors. B spoke at times of retardation of kinæsthetic report from the hand. As before, when there was articulatory distraction, there was a lengthening of the time needed for writing.

V. Writing while Counting Mentally the Number of Times that a Particular Word Occurred in a Rhyming List Read Aloud by the Experimenter.

(Normal time of writing verse for day, June 3, 61s.)

A. *No Directions as to Attention. Eyes Blindfolded.*

One trial.

(*a*) Distraction was perfect. Writing was much more automatic than ever before. There was little return of attention to movement.

(*b*) At long intervals an auditory writing-cue was obtained and there was a vague kinæsthetic report of writing very rapidly.

(*c*) Time required for writing, 65s. Lapses: 4.

General Summary.—Attention went to the distracting

rather than to the writing process. To focus attention on the motor side of the writing process, either the kinæsthetic report or the visual report, was to disorganize the movement. To intensify the writing-consciousness, B concentrated on the anticipatory side and emphasized the *auditory* aspect of the vocal-motor cue. At times there was a doubling of the vocal process. Such a method of intensification introduced conflicts with an articulatory distraction—conflicts partly resolved by the dissociation of auditory and articulatory imagery. Reading mentally caused less conflict than did articulation, and writing became more automatic but gave evidence of many lapses. There was a strong tendency to write the words being read. When distraction became *complete* in V, there was complete surrender to grapho-motor automatism and the time required for writing the verse approximated the normal. There were fewer lapses in V than in II, B, a test in which writing also approached automatism, due perhaps to the fact that the *auditory* appeal to attention was stronger than the visual appeal, and distraction consequently more *complete,* or that the verse sequence was more perfectly mastered at the time of the later test. B was the only reagent, except A, who succeeded in writing during the distraction of test V, a distraction which permitted little oscillation of attention. B's success in this test is evidence of the high degree to which his writing is automatised. The completeness of the distraction testifies to the appeal made to B's attention by the *auditory* factor. The result is perfectly characteristic of the subject.

Many lapses occurred in B's writing of the verse, due, he asserted, to the lapsing or retarding of the grapho-motor report. The sudden and unnecessary return of attention to the writing would occasion a repetition of the letters just written, of the writing of which B had had no report. Observation of the errors made show, further, that a letter was often omitted because of its graphic similarity to some letter just made; or a letter was split and its parts occurred separately—a purely motor lapse.

DISTRACTION EXPERIMENTS. VERSE.

SUBJECT D.

(Time of writing verse after perfectly memorized, for ten trials, 74.3s.; M.V., 2.6s.)

I. COUNTING ALOUD AND WRITING. EYES OPEN.

(Normal time of writing for day, January 31, 74.3s. Normal rapidity of counting, 132 in 60s. One trial each for counting and writing.)

A. *Attention Undirected.*

One trial.

(*a*) The experiment was pleasant and exciting. It did not involve the effort noticed in reading and writing at the same time. There was little oscillation of attention; but, also, but very little meaning to writing. The sight of the result was reassuring and attention was concentrated mainly on the visual perceptual result.

(*b*) Writing was guided by visual perception of the result. D watched intently the words as they flowed from the pen. There was no consciousness of incipient articulation.

(*c*) Time required for writing, 73.2s. Number counted, 123. Lapses, 0; but the writing was nervous.

B. *Attention on Counting.*

One trial.

(*a*) D counted slowly with a raised and monotonous voice in the effort to force attention on the sound of the voice. It was difficult to keep attention on the counting. The visual perception of the writing was so distracting that D felt that she could follow directions better if the eyes were closed. (Cf. IV. B.)

(*b*) There was a little auditory-motor vocalization used as writing-cue. The chief cue, however, seemed to be the contact sensations. There was a strong tendency to look off the paper.

(*c*) Time required for writing, 68s. Number counted, 108. Lapses: 1, viz., one repetitionary loop.

C. *Attention on Writing.*

One trial.

(*a*) The counting was largely automatic with occasional jerks of attention in its direction. There was little meaning to either process.

(*b*) The writing-cue was auditory-vocal-motor with an intensification of the auditory aspect. Attention also followed assiduously the visual perceptual series.

(*c*) Time required for writing, 67.6s. Number counted, 131. Lapses: 0; but writing is highly nervous, movements were uncontrolled.

Summary.—The writing-control was largely visual-perceptual, a control by seen result of movement, not by anticipation. When attention was directed to a specific process it was enforced, for counting, by a voluntarily intensified auditory-sen-

sational series; for writing, by intense visual concentration on the letters as they were written and also by the appearance of a vocalization-cue with a strongly marked auditory aspect. D's report that writing was facilitated by counting was confirmed by the lowering of the time-readings.

II. Reading Mentally and Writing.

(Normal time of writing for January 17 and January 24, 78s. and 77s.)

A. *Attention Undirected.*

One trial (January 17).

(*a*) There was oscillation of attention but with intensification of the whole process. The experiment was pleasant, although there was a distressing sense that the hand-movement was inadequate. It felt irresponsible as to details. The eye dwelt on the reading-list, word by word, in attempt to get meaning into the words. The pull of the eye from list to writing was noticeable. D was also conscious of the hand in the periphery of vision.

(*b*) The writing-cue was auditory-vocalization. There were occasional glimpses of a visual report at places where the grapho-motor report seemed slip-shod. There was at places, perhaps, a complete lapse of kinæsthetic report from the hand.

(*c*) Time required for writing, 66.8s. Number of words read, 39. Lapses: 2; omission of letter, 1; repetition of letter-part, 1.

B. *Attention on Reading.*

Two trials (January 17 and January 24).

(*a*) First trial. D found the experiment difficult since attention went to the writing rather than to the reading. Attention was, probably, on the writing during a greater part of the time. D attempted to force attention on the reading by vocalizing the words read, but this introduced conflict with the writing-cues. D also attempted to force attention on reading by movements of the head and by narrowing the eyes. Second trial. D succeeded in obeying directions only for a few seconds at a time. She enforced the reading process by an emphatic vocalization. When attention returned to writing, the writing-cues were also auditory-vocal-motor.

(*b*) First trial. The writing-cue was auditory-vocal-motor. There was a conflict of the processes utilized in reading and writing. The auditory aspect of the writing process was more pronounced than that of the reading process. Second trial. The writing-cue was auditory-vocal-motor but with a more pronounced auditory aspect than the vocal reading-process.

(*c*) Time required for writing: first trial, 75.4s.; second trial, 77s. Number of words read: first trial, 44; second trial, 68. Lapses: first trial, 6; repetition of letter-parts, 3; omission of letter-parts, 2; doubtful, 1. Second trial, 4; repetition of letter-part, 1; substitution of word-part, 1; omission of a word, 1, (D left a blank space, being unable to recall word); writing of 'its' for 'it,' 1.

C. *Attention on Writing.*

One trial (January 24).

(*a*) Most of the words were vocalized although some were merely seen. Attention was kept on the writing by utilizing a visual report from writing. This report was very distinct. Attention was strongly visual. D bent low over the writing-table and there was a feeling of eye-strain.

(*b*) The writing-cue was auditory-vocal-motor. The words came in long series, probably reading ceased at these moments. The *visual report* was complete and distinct.

(*c*) Time required for writing, 83s. Number of words read, 33. Lapses: 1; omission of letter-part, 1.

Summary.—The writing-cues in this experiment were chiefly auditory-vocal-motor with a pronounced auditory aspect. Attention was enforced on reading by the intensification, probably, of the motor side of the mental vocalization; on writing, by concentration on a visual report. The latter method of enforcement retarded writing somewhat. Except in C there was frequent lapsing of kinæsthetic report from the hand. That the test is somewhat more difficult than I, where there was visual perception of results, is shown by the greater number of lapses. As in I, however, the distracting process intensified the whole experience and the time-readings were below, or approximated, the normal.

III. Reading Aloud and Writing.

(Normal time of writing for day, February 21, 73.4s.)

A. *Attention Undirected.*

One trial.

(*a*) The experiment required effort. There was some oscillation of attention. D read rapidly, almost automatically. Although there was little sense of meaning in going from line to line of writing, the writing did not seem automatic.

(*b*) The writing-cue was auditory-vocal-motor. There was, also, a certain amount of visual report which may have served as cue to some extent.

(*c*) Time required for writing, 74s. Number of words read, 80. Lapses: 4; omission of letter-part, 2; repetition of letter-part, 1; substitution of word, 1. D wrote only the first two letters of substituted word, then crossed them out and went on with the correct word.

B. *Attention on Reading.*

One trial.

(*a*) D read intently. At times the voice was very loud and its pitch was raised. Once or twice there was a tendency to pronounce out loud the words that were being written. One word was actually so spoken, but D was unaware of the fact that it belonged to the writing-sequence.

(*b*) The writing-cues were auditory-vocal-motor but there were fewer cues present than in A. Meaning-consciousness (?) was utilized at places in getting a cue.

(*c*) Time required for writing, 79.8s. Number of words read, 79. Lapses: 5; repetition of letter-part, 1; substitution of letter (from reading), 1; omission of letter, 1; transposition of letter, 1; anticipation of letter, 1, corrected.

C. *Attention on Writing.*

One trial.

(*a*) There was little fluctuation of attention. D read slowly and laboriously and yet automatically, the reading process seemed, in general, a more automatic one than the writing process. Attention went so naturally to writing that the conditions of the experiment brought the subject great relief.

(*b*) The writing-cue was auditory-vocal-motor with the visual report also utilized as cue.

(*c*) Time required for writing, 79.2s. Number of words read, 58. Lapses: 2; repetition of letter-part, 1; substitution of word 'hath' for 'have,' a substitution immediately corrected.

Summary.—As in II, the writing-cue was auditory-vocal-motor with a varying amount of visual report, probably also utilized as a control. In III as in II the direction of attention to either process retarded the process. Attention on reading was enforced by intensification of the auditory-motor sensations; attention on writing, by automatization of the reading process, which D reported as a peculiar experience and which results show to be a more effective method than that employed in II C. In contrast to II there was little record in III of lapsing of kinæsthetic report from the hand. In comparison with II reading was carried on much more rapidly, a rapidity due perhaps to the facilitation of the meaning-consciousness by overt articulation. The time-readings were slightly above normal.

IV. Counting Aloud and Writing. Blindfolded.

(Normal rapidity of writing for day, March 2, 71s.)

A. *Attention Undirected.*

One trial.

(*a*) Pleasant excitement. Counting eased the strain on the hand normally present. Counting was automatic up to 100. During the writing of the first four lines attention was largely on the writing; during the writing of the fifth and sixth lines it seemed to be diffused over counting and writing. Convulsive movements of the hand were noticeable in places.

(*b*) The principal writing control was the visual report from writing. At one or two places where D hesitated an auditory word-cue was used.

(*c*) Time required for writing, 67s. Number counted, 132. Lapses: 3; repetition of letter-part, 1; repetition of letter, 1; repetition of word, 1, this word was written, then crossed out and rewritten. In counting, 79, 89 and 99 were omitted.

B. *Attention on Counting.*

One trial.

(*a*) Very hard to keep attention on counting. D counted slowly and in a loud labored voice. There was also a faint visual accompaniment to counting. Breathing was labored; head thrown back; eyes frequently not focused on paper.

(*b*) There was much hesitation in writing. As control, auditory-motor vocalization was used frequently; visual report was also utilized. There was, however, less visual report than in A.

(*c*) Time required for writing, 85s. Number counted, 107. Lapses: 2; repetition of letter-part, 1; omission of letter-part, 1.

C. *Attention on Writing.*

One trial.

(*a*) D bent very low over the table concentrating attention on the visual report from the writing, which was very fine and even. Down to the fourth line attention was thoroughly occupied with the writing. Up to this point D counted in a low-pitched subdued even voice. At the fourth line D's attention wandered from the writing, due to speculation as to the reason for omitting certain numerals in counting in B. At this point the voice became louder and more labored and the visual report from writing lapsed somewhat.

(*b*) There were auditory-vocal-motor cues throughout; the lines were said as wholes. Attention, however, was on the visual report which was very distinct and seemed effective as control.

(*c*) Time required for writing, 62.8s. Number counted, 117. Lapses: 3; repetition of letter-part, 1; omission of letter-part, 1; omission of letter, 1.

Summary.—The results in IV are closely comparable to those of I. In both cases, counting, which is automatic, facilitates writing. The one exception to this statement, IV B, should be compared with I B. Apparently the ideational visual control was less automatic than the perceptual visual control. In both tests visual material is prominent.

V. Writing while Counting Mentally the Number of Times that a Particular Word Occurred in a Rhyming List Read Aloud by the Experimenter.

(Normal time of writing for day, August 3, 71s.)

A. *Eyes Open.*

Three trials.

(*a*) First trial. Failure. D broke after first word of second line. Second trial. D broke at end of third line. Third trial. D wrote all of verse but last word; but after counting thirty-one occurrences of the test-word, she simply kept repeating 'forty-one' every time the test-word occurred.

(*b*) Control was largely perceptual and visual.

(*c*) Time required for writing: second trial, 41s; third trial, 88s.

B. *Eyes Closed.*

Three trials. Failures. Impossible to maintain writing under the conditions of the test.

General Summary.—Attention went normally to writing rather than to the distracting processes. Both reading and counting proved to be more automatic than writing. Counting, in fact, was so automatic as not to be a distraction at all; indeed, by release of nervous energy, it served, rather, to facilitate writing. To keep attention on counting, D intensified vocal sensations or attempted to visualize numbers. No effort was needed to hold attention on writing, but in intensification of such attention, D concentrated intensely on the visual report, either sensational or ideational, from writing. This is really a mode of concentration on the *movement-aspect* of the situation. Visual distraction was a more effective mode of distraction than articulation and sometimes disturbed the consciousness of the kinæsthetic report from the writing, a disturbance of which the reagent was distressingly aware. There was noticed a much stronger tendency to say aloud what was being written than to write what was being read (cf. A). On the whole, articulatory automatism was evident. D is aware of a tendency to such automatism in other situations likewise.

Lapses occurred rarely. When they were made, D was usually conscious of their presence and of their nature.

Distraction Experiments. Verse.

SUBJECT S.

(Average time of writing verse, after it had been perfectly memorized (eight trials), 73.24s; M.V., 1.87s.)

I. Counting Aloud and Writing. Eyes Open.

(Normal time of writing for day, February 16, 72.4s.)

A. *Attention Undirected.*

One trial.

(*a*) Experiment was difficult. Attention oscillated deliberately. There were three breaks in writing, that is, points of distinct hesitation when S found it hard to get the next word.

(*b*) The writing-cue was visual and anticipatory. This cue was necessary at the beginning of lines and in the case of difficult words. When the breaks

occurred in the writing, S was obliged to have recourse to visual perception of what had already been written, a process followed by obtaining an anticipatory visual cue of what was next to be written. At times, S noticed a tendency to articulate words of verse rather than the numbers but in general there was no consciousness of articulation of verse.

(*c*) Time required for writing, 182s. Number counted, 209. Lapses: 0.

B. *Attention on Counting.*

Two trials.

(*a*) First trial. S broke at end of third line. Counting was judged *not* to be automatic. Second trial. Attention was largely on counting, although between the counts attention went to the writing. Attention was enforced for the counting by listening to the sound of the voice.

(*b*) Anticipatory visual images occurred as writing-cues at difficult places, but in general they occurred less frequently than in I A. Writing control was more definitely a sensory control in terms of the grapho-motor report.

(*c*) Time required for writing: first trial (three lines), 74s.; second trial (whole verse), 127.8s. Number counted: first trial, 131; second trial, 189. Lapses: 2; repetition of letter, 1, corrected; omission of word, 1, not perceived.

C. *Attention on Writing.*

One trial.

(*a*) Oscillation of attention, for instance, at the beginning of every line where S stopped counting in order to get an anticipatory visual image. Attention throughout test was strongly visual; eyes were focused on paper.

(*b*) Many visual images were used as cues; more were in evidence than in I B. S forced attention to writing by concentrating on sensational and ideational visual processes.

(*c*) Time required for writing, 112s. Number counted, 179. Lapses: 3; repetition of letters, 2; anticipation of letter, 1, corrected. A transposition occurred in the counting.

Summary.—The test shows S's dependence upon visual processes, both sensational and ideational. These processes were utilized in enforcing attention and at points of difficulty. Although no conflict of control processes for writing and counting was reported, the effort experienced in focusing attention was evident throughout, as shown by the high time-readings.

II. Reading Mentally[3] and Writing.

(Normal time of writing for day, February 21, 77.6s.)

A. *Attention Undirected.*

One trial.

(*a*) Oscillation of attention throughout. S read about six words at a time,

[3] In general, S does not articulate in reading; but sometimes reads out loud in order better to concentrate on what he is reading.

then articulated the words of the verse. There was little articulation of the words read. S was strongly conscious of his hand and of a tendency of the eyes to follow attention. The eyes fell to the writing frequently, particularly at the beginning of lines. S also looked down when in doubt as to the next letter.

(*b*) The writing-cue was incipient articulation. No visual imagery occurred in the form either of anticipation or report.

(*c*) Time required for writing, 104.4s. Number of words read, 52. Lapses: 1; omission of letter, 1.

B. *Attention on Reading.*

One trial.

(*a*) No particular method was used to enforce attention on reading. Attention went continually to writing, from which it was brought back forcibly. There was a strong tendency for eyes to drop to paper.

(*b*) Articulation of words of verse served as the writing-cue. S tried to inhibit this articulation but could not.

(*c*) Time required for writing, 92s. Number of words read, 58. Lapses: 2; anticipation of letter, 1; substitution of word, 1, corrected.

C. *Attention on Writing.*

One trial.

(*a*) Attention forced to writing by double visual series; one, an anticipatory; the other, a report series. The visual cues and report interfered with the perception of the words being read. S, however, kept his eyes on each word until he got its meaning. There was no tendency to 'lip-motor' reading, but there was a strong tendency to drop eyes to the writing.

(*b*) The writing-cue was visual anticipation accompanied by a certain amount of articulation. The writing was also reported visually.

(*c*) Time required for writing, 92.5s. Number of words read, 37. Lapses: 1, corrected.

Summary.—In II as compared with I there was a shift in writing-control from visual to articulatory, although the visual control returned with the focusing of attention upon writing. A comparison of the time-readings for I and II shows that articulation as a distraction introduced greater disturbance than did visual distraction.

III. Reading Aloud and Writing.

(Normal time of writing for day, April 25, 74s.)

A. *Attention Undirected.*

One trial.

(*a*) Oscillation of attention. There was no tendency to write the words that were being read.

(*b*) The writing-cue was, chiefly, incipient articulation which possessed no auditory aspect. Some visual imagery was utilized as cue, but not a great deal. There was no visual report.

(*c*) Time required for writing, 160s. Number of words read, 95. Lapses: 9; repetition of letter-part, 2; repetition of word-part, 1; repetition of letter, 1; repetition of word, 1, S. was aware of this error; omission of letter-part, 3; transposition of letter-part, 1.

B. *Attention on Reading.*

One trial.

(*a*) Oscillation of attention. The act of reading calls for attention; overt articulation demands effort. No tendency to write words being read, but distinct tendency to articulate words being written.

(*b*) Either an articulatory or a visual cue necessary for every word written. There were fewer articulatory and more visual cues than in the preceding experiment. The grapho-motor report was much less prominent than it is in normal writing. S recalled no errors.

(*c*) Time required for writing, 127.5s. Number of words read, 73. Lapses: 9; repetition of letter-part, 5; repetition of letters, 1; omission of letter-part, 2; omission of letter, 1.

C. *Attention on Writing.*

One trial.

(*a*) Oscillation of attention; writing maintained at the expense of reading.

(*b*) More visual material than before;[4] it took the form both of cues and report. S was aware of no errors and had very little consciousness of his hand.

(*c*) Time required for writing, 106s. Number of words read, 49. Lapses: 2; repetition of letter-part, 1; repetition of letter, 1.

Summary.—With the return to an articulatory distraction, there was a gain in the amount of visual material over that reported in II (visual distraction) and also a retardation in speed. Articulatory and visual distraction together are scarcely more difficult than articulatory distraction alone. The double distraction produced, however, a larger number of lapses than was found in II.

IV. Counting Aloud and Writing. Blindfolded.

(Normal rapidity for day, March 7, 72.4s.)

A. *Attention Undirected.*

One trial.

(*a*) S broke down in the middle of the fifth line in the *middle* of a *word* and was unable to recover himself although counting was continued for several seconds after the break.

(*b*) There was a visual cue, clearly anticipatory, at the beginning of each line, varying from whole to one or two letters of the first word. There was also some articulation of words between counts, although not every word was articulated. At places the writing approached automatism.

[4] S thinks that repetition of experiment under any conditions of attention would show increase in visual material. The method is workable.

(*c*) Time required for writing, 103.2s. Number counted, 146. Lapses: 1; omission of letter-part, 1.

B. *Attention on Counting.*

One trial.

(*a*) S tried to enforce attention on counting by listening to the sound of his own voice. He was not able to keep attention on counting throughout the test.

(*b*) Visual cues occurred rarely. When there was hesitation S. was conscious of articulatory cue. This articulation produced no tension in throat muscles and had no auditory aspect.

(*c*) Time required for writing, 109.7s. Number counted, 153. Lapses: 1; omission of letter-part, 1.

C. *Attention on Writing.*

One trial.

(*a*) Attention was not concentrated wholly on writing. It was difficult to keep attention from reverting to counting, for the latter process is not wholly automatic.

(*b*) During the writing of the first two lines S made frequent use of visual cues without articulation. He broke temporarily at the close of the second line and was obliged to go back and articulate these lines before going on with the writing. From this point on S made use of articulatory writing-cue.

(*c*) Time required for writing, 120.4s. Number counted, 158. Lapses: 2; repetition of letter-part, 1; substitution of word, 1, corrected immediately.

Summary.—As before, articulatory distraction caused difficulties. With the loss of the visual perception of the result, there was an increase in the number of vocal-motor cues, but on the whole the methods of control employed in I and IV are similar.

V. Writing while Counting Mentally the Number of Times that a Particular Word Occurred in a Rhyming List which was Read Aloud by the Experimenter.

(Normal rapidity for day, July 27, 71.2s.)

A. *Eyes Open.*

One trial (failure).

(*a*) S broke at the end of the second line. There was conflict of the vocal-motor processes used for writing-cue and for counting rhymes.

(*b*) A visual ideational cue at the beginning of every word; then grapho-motor control.

(*c*) Time required for writing, 45s. (two lines). Lapses: 0.

B. *Eyes Closed.*

Two trials (failures).

(*a*) First trial. S broke at end of third line. Second trial. S broke in middle of third line. Articulatory conflict.

(*b*) Writing-cue was articulatory in both trials.

(*c*) Time required for writing: first trial, 48.2s. (three lines); second trial, 51.2s. (two and a half lines). Lapses: first trial, 2; second trial, 2.

General Summary.—Attention went to writing rather than to the distracting process, when the distracting process was visual. When the distraction was articulatory, there was deliberate oscillation of attention. Counting was not at all automatic. Throughout the tests, much visual material, both anticipatory and report processes, was used. In intensification of writing-consciousness S made use of both visual anticipation and visual report. In II C this visual material conflicted somewhat with the reading. In II A there is some evidence of a 'shunting' of control from visual to vocal-motor. There are few lapses recorded. (The results obtained from S should be compared with those obtained from Y; but writing is much better automatized for S than for Y. Neither shows much vocal-motor automatism.)

Distraction Experiments. Verse.

SUBJECT Y.

(Average time of writing verse, after it had been perfectly memorized (ten trials), 78.51s.; M.V., 3.014.)

I. Counting Aloud and Writing. Eyes Open.

(Normal time of writing for day, January 22 and January 29, 80.4s. and 78s. Normal rapidity of counting, 124 in 60s., January 22, and 125 in 60s., January 29. One trial each for writing and counting.)

A. *Attention Undirected.*

One trial (January 22).

(*a*) Marked oscillation of attention. Visual perception of word being written distracted attention from counting. Attention chiefly on writing. Conflict of visual imagery accompanying vocalization[5] of verse and counting.

(*b*) Writing-cue was vocal-motor and visual-vocal.

(*c*) Time required for writing, 165s. Number counted, 121. Lapses: 3; repetition of one letter, 1; anticipation of letter, 2. All the lapses were corrected.

B. *Attention on Counting.*

One trial (January 29).

(*a*) Marked oscillation of attention; tendency for attention to follow visual perception. Y found the experiment very difficult, due, he reports, to the fact

[5] This imagery was apparently the visualization of the position of the vocal organs.

that the sight of the writing distracted attention from counting (but cf. IV) and due also to articulation conflict. The words of the verse were articulated usually between the counting intervals.

(*b*) Writing-cue articulatory.

(*c*) Time required for writing, 178s. Number counted, 160. Lapses: 1; substitution of word, 1. In the counting Y. jumped from 130 to 140.

C. *Attention on Writing.*

One trial (January 29).

(*a*) Y wrote the first letter of the verse before he began to count. Counting was not at all automatic for him. There was a strong tendency to articulate aloud the verse-words. There were frequent conscious blanks in which he failed to get the needed word.

(*b*) Control was largely articulatory, although there was present at intervals anticipatory visual imagery.

(*c*) Time required for writing, 130.4s. Number counted, 119. Lapses: 4; repetition of letter-part, 1; anticipation of letter, 3, corrected. Many mistakes occurred in counting, most of which were corrected. Y., however, jumped from 87 to 89 and from 97 to 197 without noticing the mistake.

Summary.—Y's writing control in this experiment was articulatory and also, probably, as shown by the test on the phrase and name, grapho-motor, the latter being reported in both sensational and ideational terms. The disturbance introduced by the articulatory distraction resulted, apparently, in part from a conflict in processes, but in part also from a reluctance to allow processes to proceed without supervision. Lip-innervation seemed to interfere with hand-innervation. The shifting of attention was a labored process.[6]

II. Reading Mentally and Writing.

(Normal time of writing for day, February 6, 78s.)

A. *Attention Undirected.*

One trial.

(*a*) Attention oscillated. Y read only at intervals. Reading at times was merely visual; at other times auditory and articulatory as well as visual. Attention went naturally to writing, Y being more than normally conscious of what was being written. The hand and the writing-movement fell in the peripheral field of vision and there was a strong tendency for the eyes to fall to the writing. There was a conscious attempt to split field of vision into central and peripheral portions.

(*b*) Writing-cue not reported.

(*c*) Time required for writing, 101.4s. Number of words read, 39. Lapses: 4; repetition of letter-part, 2; omission of letter-part, 1; omission of letter, 1.

[6] Y reports, in general, considerable inertia in mental processes.

B. *Attention on Reading.*

One trial.

(*a*) Whenever attention was really on the reading there was a tendency to write the words that were being read. Attention was kept on the reading by articulation of words read; at times this articulation was audible.

(*b*) The writing-cue was articulatory.

(*c*) Time required for writing, 146.6s. Number of words read, 39. Lapses: 8; repetition of letter-part, 3;[7] repetition of letter, 1; repetition of word, 1; omission of letter-part, 2; omission of letter, 1.

C. *Attention on Writing.*

One trial.

(*a*) Oscillation of attention, although the words were read visually.

(*b*) The writing-cue for the first three lines of the verse was articulatory; for the last three lines a not wholly successful attempt was made to throw attention on hand-movement (grapho-motor report) and use this as control. There was a visual report in several places but this report was thought *not* to serve as *cue*. Attention was on the hand-kinæsthetic report; each movement a cue for the next one.

(*c*) Time required for writing, 103.8s. Number of words read, 10. Lapses: 2; repetition of letter-part, 2.

Summary.—In general, II as compared with I shows, as evidenced by the time-readings, less disturbance from visual than from articulatory distraction, a result due perhaps to absence of conflict of articulatory processes; when this conflict returns, in II B there is a noticeable increase in the time of writing. Effort to attend and rely upon the hand-kinæsthetic series is more apparent in II than in I.

III. Reading Aloud and Writing.

(Normal time of writing for days of experiment, February 20 and February 27, 73s. and 82.2s.)

A. *Attention Undirected.*

Two trials.

(*a*) First trial. Y read very calmly and deliberately; no 'flickering' of attention. Second trial. Y tried to keep his attention on reading. When meaning was got from the words read there was a strong tendency to write the words.

(*b*) First trial. Y articulated every word written; in some words there was throat-; in some, tongue-; and in others, lip-innervation. This articulation had little auditory accompaniment. Visual report from the writing made

[7] This repetition consisted each time of an extra stroke on an 'm.' Y reported that in general there is need of a faint visual cue if he is to write well. When, as in the case of an 'm,' the hand-movement outruns the visual control, the movement is poorly coördinated; the loss of control is sometimes apparent in the following syllable likewise.

evident that this cue was inadequate. There were no anticipatory visual cues. Second trial. Throat-innervation for every word written but hand did not follow this cue accurately. Errors were reported in kinæsthetic terms supplemented by a visual report. Y voluntarily allowed the question of letter-formation to drop out of consciousness.

(*c*) First trial. Time required for writing, 168s. Number of words read, 44. Lapses: 14; repetition of letter-part, 3; repetition of letter, 6; repetition of syllable, 1; omission of letter, 2; exchange of letter, 1; substitution of word, 1, corrected. Letters were so badly formed that it was hard to determine the nature of the error. Y was aware of some of the errors through the visual or grapho-motor report, although the report was not detailed.

Second trial. Time required for writing, 148s. Number of words read, 63. Lapses: 13; repetition of letter-part, 6; repetition of letter, 2; omission of letter-part, 2; omission of word, 2; exchange of letter, 1; substitution of letter, 1. Letters were so badly formed as to make classification of errors difficult.

B. *Attention on Reading.*

Two trials (February 20 and February 27).

(*a*) First trial. Y read more rapidly and spasmodically than in A, particularly in the first part of the verse. Attempt was made to keep attention on reading by articulation of each word as soon as seen. Second trial. Y was tired at time of experiment. The test demanded great effort and left Y exhausted. There was great muscular strain experienced throughout test. Attention oscillated between writing and reading with no synchronizing of processes. It took distinct effort to complete the writing of words even after they had been once started.

(*b*) First trial. The writing-cue was the articulation of every word and in some cases of the letters also. Second trial. Distinct articulation of every word. Some errors were reported visually.

(*c*) First trial. Time required for writing, 155s. Number of words read, 70. Lapses: 16; repetition of letter-part, 7; repetition of letter, 2; omission of letter-part, 1; omission of letter, 4; omission of word, 1; anticipation of letter (letter split), 1. Second trial. Time required for writing, 140s. Number of words read, 80. Lapses: many of the words end in a meaningless scrawl. One whole line, the second, is omitted; so far as estimation is possible there are 16 lapses, viz., repetition of letter-part 1; repetition of letter, 1; omission of letter-part, 1; omission of letter, 3; omission of syllable, 1; omission of words, 5; anticipation of letter, 2; unclassified, 2.

C. *Attention on Writing.*

One trial (February 27).

(*a*) The attention was actually on the reading, not the writing. The experiment was disagreeable and very fatiguing. The whole coördination was broken by inhibiting the tendency to write the word that was being read.

(*b*) The writing-cue was throat-articulation; sometimes, actual lip-articulation.

(*c*) Time required for writing, 158.2s. Number of words read, 70. Lapses: 8; repetition of letter-part, 2; repetition of letter, 2; omission of letter-part, 1; omission of letter, 1; omission of word, 2.

Summary.—These experiments were so fatiguing and disagreeable to Y that several tests were omitted. There is evident, as in I, conflict of articulatory processes, with an accompanying increase in time-readings. But in comparison with I, the loss of visual perceptual guidance is evident, as shown by the increased number of lapses. Y attempted to allow the hand-movements to run themselves in III, in contrast to II, with the result that the coördinations went badly adrift, as was evidenced both by the lapses and the malformation of letters. The increase in the number of words read in III as compared with II shows again the bid made by the articulatory process upon attention.

IV. COUNTING ALOUD AND WRITING. BLINDFOLDED.
(Normal rapidity for day, March 7, 73.6s.)

A. *Attention Undirected.*

One trial.

(*a*) There was oscillation and dispersion of attention. When attention left the writing there was a tendency to write the word that was being pronounced.

(*b*) The writing-cue was articulatory, word- and letter-cue, but the cues were less prominent than in the normal writing for the day. At times, there was a visual report from the writing. Intrusion of meaning-consciousness was annoying.

(*c*) Time required for writing, 163s. Number counted, 86. Lapses: 11; repetition of letter-part, 3; omission of letter-part, 3; repetition of letter, 4; anticipation of word, 1, immediately corrected. Y. was also aware through the visual report of the repetition of one letter.

B. *Attention on Counting.*

One trial.

(*a*) Y counted six before beginning to write; he counted more rapidly than before; attention a great part of the time was not on the counting at all.

(*b*) Very little articulation was used as writing-cue except when there was difficulty in getting a word started. The cue was an anticipatory visual cue of hand, pen, and word to be written. Many of the lapses were reported. When report was in grapho-motor terms and 'fixed visually' Y was able to specify error. Otherwise he was only aware that a mistake had been made.

(*c*) Time required for writing, 178.8s. Number counted, 120. Lapses: 10; repetition of letter-part, 3; repetition of letter or letters, 3; repetition and anticipation of letter, 1; omission of letter-part, 1; omission of letters, 2.

C. *Attention on Writing. No Test.*

Summary.—IV shows more anticipatory visual material than do the other distraction tests. It is closely comparable

with I, the ideational visual material supplying to a certain extent the control furnished perceptually in I. The former control is, however, less efficient than the latter as is evidenced by the greater number of lapses in IV. The time-readings in both cases are high.

V. WRITING WHILE COUNTING MENTALLY THE NUMBER OF TIMES THAT A PARTICULAR WORD OCCURRED IN A RHYMING LIST READ ALOUD BY THE EXPERIMENTER.

(Normal time of writing for day, August 2, 73s.)

A. *Eyes Open.*

Two trials.

(*a*) First trial. Failure. Y broke completely at the end of the second line. Mental articulation used in counting words conflicted with the vocal-motor cue for writing. Counting could not go on visually although the results from the counting were so held. Second trial. Y broke at end of first line. The visual perception of the writing distracted attention from counting.

(*b*) First trial. The writing-cue was articulatory. Second trial, no report.

(*c*) Time required for writing. First trial (two lines), 40s. Second trial (one line), no record. Lapses: first trial, one repetition of letter-part. Second trial, omission of two letters.

B. *Eyes Closed.*

Two trials (failures).

(*a*) First trial. Y broke after second word. Second trial. Y broke in the middle of second line.

(*b*) Writing-cue, second trial, was articulatory. There was also a visual report from writing which conflicted with the visualizing of the numbers.

(*c*) Time required for writing, second trial (one and a half lines), 40s. Lapses: 7; repetition of letter, 3; omission of letter, 4; anticipation of letter, 1.

General Summary.—Attention went to writing rather than to the distracting process when the distracting process was visual. When the distracting process included articulation there was great conflict. Hand and vocal innervation seemed to inhibit each other. Counting was not at all automatic; the nearest approach to automatism was found in mental reading; the test involving this distraction is slightly less difficult than the other tests. Part of the difficulty for Y in the articulatory conflict was due to the use of a small verbal unit, usually the word or letter. In intensifying writing consciousness, attention was focused on the report of hand-movement and this movement was at times changed to a finger-movement in order to enforce consciousness. When attention was actually

on reading, there was a tendency to write the words read; at other times a tendency to say aloud the words being written.

Y's results should be compared with those of S; but Y found the experiment even more difficult than did S; writing is for him even less automatic than for the latter.

Y's record shows a very great number of lapses (80); this again is in contrast to the record of S.

Distraction Experiments. Writing of Verse.

SUBJECT R.

(Average time of writing verse, after it had been perfectly memorized (ten trials), 70.34s.; M.V., 2.644s.)

I. Counting Aloud and Writing. Eyes Open.

(Normal time of writing for day, November 13, 71s. Normal rapidity of counting, 153 in 60s. One trial each for writing and counting.)

A. *Attention Undirected.*

One trial.

(*a*) Attention flickered rapidly, returning to the verse at the beginning of lines. The conflict was greatest where numerals occurred in both processes. In the fourth line of writing the words to be written were interpolated between the separate counts. During the writing of the sixth line consciousness of writing lapsed at intervals.

(*b*) The writing-cue was probably auditory-vocal-motor.

(*c*) Time required for writing, 73.8s. Number counted, 133. Lapses: 3; omission of word, 1; substitution and repetition, 1; R started to write 'September' for 'November' but corrected the error; reversion to another wording of verse in the sixth line, 1.

B. *Attention on Counting.*

One trial.

(*a*) R counted in a louder voice than in A. Attention so far as it was focused on counting was concentrated on the sound of the voice. There was some oscillation of attention; but in the writing of the fifth and sixth lines attention was on the writing.

(*b*) The writing-cue in the first two lines was the grapho-motor sensational series. In the following lines auditory-vocalization was used at the beginning of lines and at difficult places.

(*c*) Time required for writing, 72.6s. Number counted, 148. Lapses: 3; omission of letter-parts, 2; omission of letter, 1.

C. *Attention on Writing.*

One trial.

(*a*) The test required more effort than did A. R counted in a low voice.

(*b*) The writing-cue was auditory-vocal-motor, word by word.

(*c*) Time required for writing, 78.5s. Number counted, 109. Lapses: 2; omission of one letter-part, 1; substitution of word, 1, corrected.

Summary.—Writing was so well organized in grapho-motor terms that the introduction of the counting process caused little disturbance, although there was considerable fluctuation of attention. Some auditory-vocal-motor cues were needed at intervals in writing the verse, and visual attention was utilized throughout. Attention on counting was enforced by intensification of auditory sensations; attention was focused on the sound of the voice. It required effort to give attention to writing and in doing so, R used more auditory-vocal-motor cues than under other conditions.

II. Reading Mentally and Writing.

(Normal rapidity of writing for day, November 8, not obtained.)

A. *Attention Undirected.*

One trial.

(*a*) There was some fluctuation of attention. The words read were vocalized mentally. Attention was on the writing at the points where an auditory-vocal-motor cue was found necessary, or at places where the hand-kinæsthetic report gave notice of an error.

(*b*) The writing-cue was largely automatic, a surrender to the grapho-motor sensational series. Auditory-vocal-motor cues were needed to get the lines started.

(*c*) Time required for writing, 80s. Number of words read, not reported. Lapses: 3; omission of word, 1; intrusion of letter, 1, immediately corrected; writing of small for capital letter, 1, reported kinæsthetically.

B. *Attention on Reading.*

One trial.

(*a*) Some oscillation of attention. Attention was kept on reading by mentally pronouncing every word. When attention went to the writing it was centered on the hand-movement. There was no visual material.

(*b*) No writing-cues were reported. The hand-kinæsthetic sensations were directive.

(*c*) Time required for writing, 68s. Number of words read, not reported. Lapses: 1; omission of a word.[8]

C. *Attention on Writing.*

One trial.

(*a*) Required even less effort than B.

(*b*) Auditory-vocal-motor cues were used throughout. The first line was spelled out letter by letter; the other lines were syllabified. There was little

[8] Omission of this word was a frequent error.

visualization, except in the last line where a small letter was incorrectly written for a capital one. This error was reported visually, and the report was followed by a visual image of the correct letter.

(*c*) Time required for writing, 66s. Number of words read, not reported. Lapses: 3; repetition of letter-part, 1; omission of word, 1; writing of small for capital letter, 1, corrected.

Summary.—This test like I shows a well-developed writing-automatism. Attention was maintained on reading by mental vocalization of the words read, and on writing by the same method. Very little visual material was present in writing. The time-readings for the writing of the verse are even lower than those in I, indicating probably that visual distraction caused even less conflict than did articulatory distraction. The relatively high time-reading in A was, perhaps, due to the novelty of the experiment.

III. Reading Aloud and Writing.

(Normal time of writing for day, November 13, 71.4s.)

A. *Attention Undirected.*

One trial.

(*a*) The experiment required effort. Attention flickered.

(*b*) An auditory-vocal-motor writing-cue was used frequently.

(*c*) Time required for writing, 84s. Number of words read, no record. Lapses: 3; omission of letters, 2; omission of letter-part, 1; R. was conscious of these mistakes but could not avoid making them. In reading the list several words were omitted.

B. *Attention on Reading.*

One trial.

(*a*) R found it difficult to keep attention on the reading. Several words were omitted from the reading-list.

(*b*) An auditory-vocal-motor writing-cue was used frequently.

(*c*) Time required for writing, 80.4s. Number of words read, not reported. Lapses, 4; omission of letter-part, 1; omission of letter, 1; repetition of letter-part, 1; substitution of letter, 1.

C. *Attention on Writing.*

One trial.

(*a*) R found the experiment difficult. In reading the list words written were interpolated, while words that belonged in the list were dropped from it. There was much hesitation in reading and little meaning in what was read.

(*b*) R used an auditory-vocal-motor cue, word by word. At one place she glanced down at paper.

(*c*) Time required for writing, 85.4s. Number of words read, no record. Lapses: 6; repetition of word, 1; of letter, 1; omission of letter, 2; substitution of letter, 1; reversion to another wording of verse.

Summary.—Overt articulation of the words read caused difficulties and raised the time-readings. As before, attention was concentrated on writing by slow vocalization.

IV. Counting Aloud and Writing. Blindfolded.

(Normal time for day, November 19, 71.3s.)

A. *Attention Undirected.*

One trial.

(*a*) Attention flickered rapidly from writing to counting. R lost count once but corrected her mistake.

(*b*) The words written were vocalized mentally. There was also a little visualization used as cue at the beginnings of lines. In one place the articulation of the verse-words was audible.

(*c*) Time required for writing, 78s. Number counted, 139. Lapses: 2; omission of word, 1; repetition of letter, 1; R. reported this error of which she became conscious, first through the grapho-motor, then through the visual report.

B. *Attention on Counting.*

One trial.

(*a*) R counted very rapidly and reported that the rapidity of the counting process hastened the writing for the two processes were rhythmized. There was less oscillation of attention than before.

(*b*) A few auditory-vocal-motor cues were used at intervals.

(*c*) Time required for writing, 64.4s. Number counted, 151. Lapses: 6; repetition of letter-part, 1; omission of letter, 2; omission of word, 2; substitution of letter, 1. Writing was nervous.

C. *Attention on Writing.*

One trial.

(*a*) The attention was concentrated on the hand and its movements. R more aware of kinæsthetic sensations from the hand than ever before.

(*b*) The control was consciously grapho-motor. There was little articulation of the verse.

(*c*) Time required for writing, 82.2s. Number counted, 150. Lapses: 3; repetition of letter-part, 2; repetition of letter, 1.

Summary.—As in the other tests there was evidence of articulatory conflicts. In focusing attention on the writing, R in this experiment attempted to concentrate on the hand and its movements, a method which retarded writing although reducing articulatory conflict. As compared with I results from IV evidence the loss of visual perceptual control.

V. WRITING WHILE COUNTING MENTALLY THE NUMBER OF TIMES THAT A PARTICULAR WORD OCCURRED IN A RHYMING LIST THAT WAS READ ALOUD BY EXPERIMENTER.

(Normal time of writing for day, August 3, 63s.)

A. *Eyes Open.*

One trial (failure).

(*a*) Very difficult. Break at beginning of third line where R. returned to wording of first line.

(*b*) Surrender to grapho-motor sensations but with certain number of anticipatory vocal-motor cues.

(*c*) Time required for writing (two lines and a half), 45s. Lapses, a return to first words of first line.

General Summary.—Attention went to the distracting process rather than to writing. To focus attention on the actual writing-movement as in IV C retarded writing. Usually in intensifying the writing-consciousness R made use of slow vocalization, word by word, or even letter by letter. Such a method of intensification introduced slight conflicts with articulation, so that mental reading as a distraction caused less conflict than did the other methods of distraction employed. On the whole, surrender to grapho-motor automatism was an adequate way of meeting distraction. There were few errors made in writing. Part of R's success in dealing with the distractions was due to a wonderfully rapid oscillation of attention from process to process.

DISTRACTION EXPERIMENTS. WRITING OF VERSE.

SUBJECT A.

(Average time of writing verse, after it had been perfectly memorized (11 trials), 56.8s.; M.V., 3.91s.)

I. COUNTING ALOUD AND WRITING.

(Normal time for day, November 21, 57s.)

A. *Attention Undirected.*

One trial.

(*a*) Experiment required effort and was slightly disagreeable. A counted in a very low voice and wrote with many hesitations. Up to 100 counting was automatic at intervals; from 100 on not at all automatic. Throughout the experiment there was oscillation of attention; but more attention was given to writing during the first part of test.

(*b*) The writing-cue was auditory-vocal-motor with sensational visual control also evident. There was no ideational visual control. Twice there occurred a vague hand-motor cue, a partly anticipatory, partly sensational feeling of cramp in hand. This 'feeling' was attached to words difficult to write.

(*c*) Time required for writing, 113s. Number counted, 169. Lapses: 2; letter introduced in anticipation, 1, corrected immediately when perceived visually; omission of word ('it'), 1.

B. *Attention on Counting.*

One trial.

(*a*) A counted in a low voice. Counting-attention was enforced by ryhthmic grouping in 10's. After a group was once started the continuance was automatic. After 100 each word constituted a group. At the beginning of the experiment there was attention to throat and lips movement with anticipatory auditory-vocal-motor image of counting. Later, attention went to the auditory sensation arising from sound of counting.

(*b*) Writing-cue was auditory-vocal-motor with perceptual visual attention, although the latter was intermittent. The verse was written in the interstices of mind-wanderings from counting.

(*c*) Time required for writing, 161.2s. Number counted, 169. Lapses: omission of a *line*.

C. *Attention on Writing.*

One trial.

(*a*) Counting lower than before and more rapid. Both counting and writing more automatic than before. Ease in experiment with but little sense of certainty as to introspections.

(*b*) A uncertain as to nature of cue for writing. Probably hand-motor control with subsidence of lip-motor and visual control.

(*c*) Time required for writing, 59.6s. Number counted, 116. Lapses: omission of word ('it'), 1; frequent telescoping of letters.

Summary.—The writing-cue was auditory-vocal-motor with control visually by the seen result of writing. When attention went to writing, however, there was subsidence of awareness of such control and the process became more automatic. Attention went more naturally to writing than to counting, the latter being a highly automatic process. Attention was enforced on counting by attending to lip and throat movements; on writing, by no particular method, other than ignoring the counting process. Time of writing was greatly increased when attention was on counting or undirected; it approached the normal when attention was directed to writing. When attention was on counting, one whole line of verse was omitted without A being aware of the lapse.

II. READING MENTALLY AND WRITING.

(Normal time for day, November 14, 56.2s.)

A. *Attention Undirected.*

One trial.

(*a*) Experiment required great effort. Natural disposition was to give attention to writing. Attention, however, oscillated from verse to list of words read with marked tendency for the eye to move to the right of the column of words read, that is, toward the writing.

(*b*) Writing-cue was visual imagery of words, although image and writing overlapped somewhat. There was a successive series of visual percepts (words read) and visual images (writing-cues). Three of the lapses that occurred were spoken of as reported in visual and kinæsthetic terms. Only one of them was reported in detail.

(*c*) Time required for writing, 61.4s. Number of words read, 20. Lapses: 6; omission of letter-part ('m,' 'n,' 'u'), 4; omission of letter ('e' and 'i'), 2; frequent telescoping of letters.

B. *Attention on Reading.*

One trial.

(*a*) Attention oscillated but was on the reading at beginning of the test. Consciousness was largely perceptual. Associative processes set up by list.

(*b*) Writing-cue. A pushed through writing with a brief series of visual images. There was a greater tendency than in II A to use auditory-verbal-motor images, this being particularly the case when A was in difficulty. A spoke of many lapses, which he was unable to specify, as reported kinæsthetically. (See test C below.)

(*c*) Time required for writing, 149s. Number of words read, 82. Lapses: 3; omission of letter, 2; repetition of letter-part, 1; telescoping of letters.

C. *Attention on Writing.*

One trial.

(*a*) Attention oscillated. The reading was done in the gaps between the lines of writing. Attention was enforced on writing by auditory-verbal imagery.

(*b*) Writing-cue. A noticed a distinct shift in control from visual to auditory-verbal-motor imagery. A little visual imagery persisted but it followed rather than preceded writing.

(*c*) Time required for writing, 79s. Number of words read, 25. Lapses: 1; omission of letter, 1.

Summary.—Although the distracting process in II was visual, there emerged, in contrast to I, anticipatory visual cues, due probably to the loss of the perceptual visual control of I. The possibility of very rapid oscillation of attention from visual stimulus to visual image was shown by the low time-reading in A, where this method was employed. When, however, attention went to counting, the oscillation of attention was retarded and the time-reading greatly increased. Attention was enforced on writing by using an auditory-vocal-motor control.

III. Reading Aloud and Writing.

(Normal time of writing for day, July 10, 52.6s.)

A. *Attention Undirected.*

One trial.

(*a*) There was marked oscillation of attention.

(*b*) The writing-cue was auditory-vocal-motor with some anticipatory visual imagery but very little visual report. On the whole, the report from writing was not as distinct as usual. A few words were written automatically by the hand.

(*c*) Time required for writing, 93.6s. Number of words read, 60. Lapses: 2; omission of letter-part, 2.

B. *Attention on Reading.*

One trial.

(*a*) Attention held to reading by effort. The problem was to keep it off the writing. There was a strong tendency to speak the words being written.

(*b*) The writing-cue was auditory-vocal-motor, and the words came in phrases, a cue once given was sufficient. There was a dim visual report of words in groups. The kinæsthetic report from the hand was not very distinct. In normal writing this report is not particularly distinct, nor are such sensations significant.

(*c*) Time required for writing, 144.6s. Number of words read, 164. Lapses: 4; omission of letter-part, 2; repetition of word, 1; repetition of letter, 1.

C. *Attention on Writing.*

Two trials.

(*a*) First trial. A read in a very low hesitating voice. Second trial, oscillation of attention, A read in a low hesitating voice. Less confidence than in first trial.

(*b*) First trial. The writing-cue was anticipatory visual cue with a less noticeable auditory-vocal-motor accompaniment. There was lack of awareness of movement. Second trial. There was visual anticipation as before, but less confidence. A suspected that he had omitted one line (a false suspicion). There was a feeling of uncertainty as to longer words.

(*c*) Time required for writing: first trial, no report; second trial, 77.2s. Number of words read, no report. Lapses: first trial, 6; omission of letter-parts, 3; omission of word, 1; repetition of letter, 1; exchange of letters, 1. A reported that in several places he was not sure of having made the required number of strokes. Lapses: second trial, 2; omission of letter-part, 1; A originally wrote, 'twenty-one' instead of 'twenty-eight' and omitted the last two words of line; then returned and crossed out 'one' and wrote in the final words of line. 'One' was a repetition of word, two lines above.

Summary.—Some visual material was evident in every test, particularly when attention was on writing, on which occasion the writing-cue was visual anticipation. On the whole, the

results in III are very similar to those of II; the addition of overt articulation of words read changed results but slightly. There was a strong tendency to speak aloud the words that were being written. As before, there is great increase in the time-reading when attention is on reading; but little increase when attention is on writing.

IV. Counting Aloud and Writing. Blindfolded.

(Normal time for day, November 21, 57s.)

A. *Attention Undirected.*

One trial.

(*a*) Marked oscillation of attention. But counting more nearly automatic than writing.

(*b*) Writing-cue was visual and anticipatory. When eyes are open hand takes the initiative and the eyes are used in correction; when the eyes are closed the functions are exchanged.

(*c*) Time required for writing, 72.6s. Number counted, 94. Lapses: 1; repetition of letter-part.

B. *Attention on Counting.*

One trial.

(*a*) A more difficult experiment than A for counting, particularly in the case of the lower digits, is automatic. The experiment as a whole less difficult than when eyes are used. Counting was enforced by listening to sound of voice.

(*b*) The writing-cue was visual and anticipatory, one or more words usually seen in 'own' handwriting at the beginning of line on a poorly illumined surface. Some articulatory imagery was also used at beginning of lines.

(*c*) Time required for writing, 87.4s. Number counted, 149. Lapses: 4; omission of letter or letter-part, 3; repetition of letter-part, 1.

C. *Attention on Writing.*

Test not tried.

Summary.—The results from IV are comparable with those obtained in I. As these tests were tried the same day, IV had the benefit of practice which may account for the lower time-readings. There is much visual material, as was true also in II and III, and also, probably, in I. As in every other test, attention to the distracting process raised the time-reading.

V. Listening to the Reading of a List of Rhyming Words and Counting Mentally the Number of Times One Particular Word Occurs while Writing.

(Normal time for day, July 11, 52.6s.)

A. *No Directions as to Attention. Eyes Open.*

One trial.

(*a*) Distraction was perfect. But in order to write, attention had to go to hand. There was oscillation of auditory perception and auditory image.

(*b*) Writing-cue was auditory. Perceptual visual control felt to be slight. No hand-automatism.

(*c*) Time required for writing, 90s. Counted 32 out of 34 times word was read. Lapses: 0.

General Summary.—Attention went normally to writing rather than to distraction processes. Both reading and counting proved to be more automatic than writing. Counting was particularly automatic. Attention was focused on counting by employing anticipatory auditory-vocal-motor images or by concentration on auditory sensations. Attention was enforced on writing by vocalization and, at times, by visual report or anticipation. There was a stronger tendency to articulate aloud words being written than to write words read (so also in the case of D).

There are comparatively few lapses, particularly those of persistence. (A's record should be compared with D's.)

DISTRACTION EXPERIMENTS. VERSE.

SUBJECT H.

(Average time of writing verse, after it had been perfectly memorized (14 trials), 80.23s.; M.V., 3.44s.)

I. COUNTING ALOUD AND WRITING. EYES OPEN.

(Normal time of writing for day, December 15, 81.4s. and 78.6s. (two trials); normal rapidity of counting, December 15, 173 in 60s. and 45 in 9s. (one trial).

A. *Attention Undirected.*

One trial.

(*a*) Counting judged to be more automatic than writing. In changing 10's there was hesitation, particularly from 100 on. After 100 counting was a slower process.

(*b*) There was a lip-motor writing-cue at the beginning of each line. At these points there was hesitation in the counting.

(*c*) Time required for writing, 67s. Number counted, 120. Lapses: 3; repetition of letter-part, 1; and omission of letter-part, 2.

B. *Attention on Counting.*

One trial.

(*a*) Attention reverted to writing only at long intervals. Attention was enforced on counting by bringing to consciousness the articulatory sensations accompanying the counting. H kept her eyes off the writing.

(*b*) There were articulatory writing-cues at infrequent intervals; otherwise the writing was automatic.

(*c*) Time required for writing, 85s. Number counted, 130. Lapses: 12; omission of letter-part, 5; omission of words, 7 (an omission of one whole line).

C. *Attention on Writing.*

One trial.

(*a*) The experiment was a difficult one since the intrusion of the auditory or lip-motor sensations incident to counting distracted attention from the writing. When attention was on the writing the counting became slower. This fact, reported in auditory terms, would again distract H's attention from the writing.

(*b*) An articulatory image was used at times to enforce attention on the writing. Attention was also enforced by concentration on the visual perceptual series.

(*c*) Time required for writing, 73.4s. Number counted, 116. Lapses: 2; omission of letter-part, 2.

Summary.—Both writing and counting seemed well automatized. They could be carried on simultaneously without difficulty, even, perhaps, with some facilitation of the writing, as shown by the low time-reading in A. The attempt, however, to throw attention on either process caused disturbance and tended to break up the coördination.

II. READING MENTALLY AND WRITING.

(Normal time of writing for day, January 4, 79s.)

A. *Attention Undirected.*

One trial.

(*a*) Oscillation of attention only when writing the first words of each line of verse. Otherwise attention was on the reading. The words of the reading-list were 'lip-motored' and there was a strong tendency to write them. This was evident in the results. The experiment required little effort.

(*b*) An articulatory writing-cue for the first word of every line except the second, for which no cue was needed. Otherwise, the writing was automatic.

(*c*) Time required for writing, 83s. Number of words read, 60. Lapses: 10; omission of letter-part or of letter, 4; repetition of letter-part, 3; transposition of letter, 1; intrusion of words from reading list, 2.

B. *Attention on Reading.*

One trial.

(*a*) A good deal of oscillation of attention. In enforcing attention on the reading there was a perceptible movement of the lips. H spoke the words read with emphasis.

(*b*) No writing-cue was reported, although there was consciousness of the hand. At the beginning of lines there was hesitation. H was conscious of some

of the errors in writing but uncertain whether the report was in articulatory or grapho-motor terms.

(*c*) Time required for writing, 105s. Number of words read, 49. Lapses: 22; omission of letter-part, 4; omission of word, 6; repetition of word, 4 (one word recurs three times); repetition of letter-part, 2; anticipation and repetition of letter, 5; intrusion of letter from list read, 1.

C. *Attention on Writing.*

One trial.

(*a*) Reading was done visually with mental articulation for only a few words. The articulatory process was used, however, to enforce attention on writing.

(*b*) The writing-cue was articulatory.

(*c*) Time required for writing, 92.4s. Number of words read, 18. Lapses: 7; omission of letter-part, 3; repetition of letter-part, 4.

Summary.—Comparison of the time readings in II and I shows that visual distraction caused greater disturbance than did articulatory distraction. This disturbance may be due to the loss of visual perceptual guidance present in I but not in II, or it may result from the fact that the visual distracting process was a less automatic one than the articulatory. As in I, concentration of attention on either process introduced additional disturbance. There is a great increase in the number of lapses compared with I. Incipient articulation was employed as a method of enforcing attention.

III. Reading Aloud and Writing.

(Normal time of writing for day, January 11, 84s. and 85s.)

A. *Attention Undirected.*

One trial.

(*a*) This experiment was found to be more difficult than II. H broke down at the end of the fourth line of writing and was unable to find writing-cue, although reading was continued for two minutes after break. H began reading in a loud voice which was gradually lowered.

(*b*) Writing-cue was articulatory at intervals.

(*c*) Time required for writing, not reported. Number of words read, 46 before break. Lapses: 8; repetition of word, 1; repetition of letter-part, 2; omission of letters, 2; intrusion of letter from reading list, 2; one word an undecipherable jumble of letters.

B. *Attention on Reading.*

One trial.

(*a*) H was conscious of writing only at long intervals, perhaps only when writing capitals. She was absolutely unconscious of the errors made in the writing, although aware, when writing stopped, of the fact.

(*b*) The writing was largely automatic. An articulatory cue was used in writing the first word of the third line but no other cues were recalled.

(*c*) Time required for writing, 69s (two lines of verse are omitted). Number of words read, 71. Lapses: very difficult to classifiy; the fourth and fifth lines of the verse are altogether wanting; an extra line inserted is a jumble of word-parts; besides these errors there is repetition of words, 2; repetition of syllable, 1; repetition of letter-part, 2; omission of word, 1; omission of letter-part, 3; anticipation of word, 1; anticipation of letter-part, 1; other lapses indeterminable, 3.

C. *Attention on Writing.*

One trial.

(*a*) This experiment was still more difficult than the preceding. The reading was not at all automatic and was done in the intervals between writing. H read very slowly. There was marked oscillation of attention. To enforce attention on writing H was obliged to articulate incipiently, occasionally even overtly, every word written.

(*b*) The writing-cue was articulatory.

(*c*) Time required for writing, 98.2s. Number of words read, 23. Lapses: 2; omission of letter-part, 2.

Summary.—The results from III give evidence of considerable writing automatism, neither writing-cue nor writing report being present except at rare intervals when attention was off writing. Since, however, the distracting process was not at all automatic, when attention was directed to writing, marked oscillation of attention occurred. In the latter case attention was enforced on writing by incipient, sometimes overt, articulation.

IV. Counting Aloud and Writing. Eyes Blindfolded.

(Normal time of writing for day, January 18, 83s. and 80s.; normal rapidity of counting, January 18, 136 in 60s.)

A. *Attention Undirected.*

(Results and introspective report show that attention was actually on the counting. The report is consequently given under B.)

B. *Attention on Counting.*

One trial.

(*a*) No effort was required. Attention was largely on counting. There was very little consciousness of writing, not even a kinæsthetic report from the moving hand.

(*b*) At long intervals there was an articulatory writing-cue.

(*c*) Time required for writing, 82s. Number counted, 140. Lapses: 7; repetition of letter-part, 4; omission of letter-part, 2; omission of word, 1.

C. *Attention on Writing.*

One trial.

(*a*) The experiment was difficult. H counted ten before beginning to write and after beginning counted very slowly.

(*b*) For the first line H used an articulatory cue which conflicted with the counting articulation. In the second, third, fourth and fifth line there was a visual cue preceding writing; short words were usually seen as wholes. In the sixth line there was a return to the articulatory cue.

(*c*) Time required for writing, 1218. Number counted, 45. Lapses: 7; omission of letter, 3; omission of letter-part, 2; repetition of letter, 2.

Summary.—In IV C, in contrast to I C and II C, visual ideational cues appeared in the effort to force attention on writing. The result is comparable to that given under I C, where attention took visual perceptual form. The use of an ideational visual series demands, however, greater effort than was noticed in I C. In IV B the loss of the visual perception of the result, facilitated concentration on the counting. This again parallels the results in I B where H voluntarily kept her eyes off the writing.

V. This test was not tried on H.

General Summary.—Attention went naturally to the distracting process, for writing was the more automatic act. When directed to writing, attention was enforced visually unless the distraction was a visual one; under the latter conditions strong articulation was used to force attention on writing. When distraction was both visual and articulatory, the effort to throw attention on writing caused much oscillation of attention and little success in dealing with the distraction process. Visual solicitation was much more effective than was articulatory, so much so that when H was focusing attention on counting, it was necessary to ignore the visual perception of the writing. Concentration on writing by use of visual anticipation was a highly effective method of enforcing attention but required great effort. A visual-articulatory distraction operated in reducing writing to automatism; many lapses occurred and the process finally broke down altogether.

In general, the automatic character of the writing act was evidenced by the number and character of the lapses. There were many errors of repetition and of omission. In the case

of the latter many were due to similarity in graphic movement so that H probably had the impression of having written the letter or letter-part. Where words were omitted there were often substitutionary repetitions. Exchange of letter-parts occurred occasionally—a purely motor lapse. The solicitation of attention by visual distraction was evidenced by the tendency in reading to insert words or letters from the list read.

3. Tables IV. and V. Tabulating Results from Seven Subjects.

Table IV.

Comparative Table. Distraction Tests. Writing of Verse.

(Key, see note 13.)

No. of Experiment.	Control. Subject B.	Time of Writing in S.	No. of Lapses.	No. Read or Counted.	Control. Subject R.	Time of Writing in S.	No. of Lapses.	No. Read or Counted.
I.[9] A.	Avm, tactile and Grm-s-r	130.8	3	120	Avm	73.5	3	133
I. B.	Avm-i-a	138.4	0	130	Avm, at intervals	72.6	3	148
I. C.	A-i-a	117.5	3	107	Avm, word by word	78.5	2	109
II.[10] A.	Avm, auditory distinct	61.2	4	39	Avm, at intervals	80	3	
II. B.	A, at long intervals	61.7	3	86	Grm-s-r, at intervals	68	1	
II. C.	Avm (double) and A-s-r	64.3	1	26	Avm, by letters & syllables.	66	3	
III.[11] A.	Avm, Grm-s-r, A-s-r	104	10	32	Avm	84	3	
III. B.	Avm	146	16	82	Avm	80.4	4	
III. C.	Avm, A distinct	75	8	26	Avm, word by word	85.4	6	
IV.[12] A.	Avm, at intervals	94	10	72	Avm, V-i-a, slight	78	2	139
IV. B.	Avm	109	16	123	Avm, at intervals	64.4	6	151
IV. C.	Avm, word by word	112	12	87	Grm-s-r, at intervals	82.2	3	150
	Subject H.							
I.[9] A.	Vm, at intervals	67	3	120				
I. B.	Vm, at intervals Ignored V-s-r	85	12	130				
I. C.	Vm, V-s-r	73.4	2	116				
II.[10] A.	Vm, at intervals	83	10	60				
II. B.	Automatic	105	22	49				
II. C.	Vm	92.4	7	64				
III.[11] A.	Vm, at intervals H. broke at end of 4th line		8					
III. B.	Automatic One line omitted	69+	15	71				
III. C.	Vm, word by word	98.2	2	23				
IV.[12] A.	See B. below							
IV. B.	Automatic	82	7	140				
IV. C.	Vm. V-i-a	121	7	45				

[9] Counting aloud.

[10] Reading mentally.

[11] Reading aloud.

[12] Counting aloud blindfolded.

[13] A, attention undirected; B, attention on distracting process; C, attention on writing. Avm, auditory-vocal-motor; Vm, vocal-motor; A, auditory; V, visual; Grm, grapho-motor; s, sensational; i, ideational; a, anticipatory; r, report.

TABLE V.

COMPARATIVE TABLE. DISTRACTION TESTS. WRITING OF VERSE.

(Key, see note 18.)

No. of Experiment.	Control. Subject D.	Rapidity in S.	No. of Lapses.	No. Counted or Read.	Control. Subject A.	Rapidity in S.	No. of Lapses.	No. Counted or Read.
I. A.[14]	V-s-r	73.2	0	123	Avm, V-s-r	113	2	169
I. B.	Avm, tactile report	68	1	108	Avm, V-s-r	161.2	6	169
I. C.	Avm, V-s-r	67.6	0	131	Grm-s-r, V-s-r, probably	59.6	2	116
II. A.[15]	Avm, slight V-s-r Lapse of Grm-s-r	66.8	2	39	V-i-a	61.4	6	20
II. B.	Avm	77.4	4	68	V-i-a, Avm	149	4	82
II. C.	Avm, strong V-i-r	83	1	33	Avm, slight V-i-a	79	2	25
III. A.[16]	Avm, V-i-r	74	4	80	Avm, V-i-a	93.6	4	60
III. B.	Avm, at intervals	79.8	5	79	Avm, V-i-r	144.6	4	164
III. C.	Avm, V-i-r	79.2	2	58	V-i-a	77.2	3	
IV. A.[17]	V-i-a, at places	67	3	132	V-i-a	72.6	1	94
IV. B.	Avm, V-i-r	85	2	107	V-i-a, Avm	87.4	4	149
IV. C.	V-i-r, Avm	62.8	3	117				
	Subject Y.				Subject S.			
I. A.[14]	V		3		V-i-a, V-s-r	182	0	209
I. B.	Vm, V-i-a	178	1	160	V-i-a, Grm-s-r	127.8	2	189
I. C.	Vm, V-i-r	130	4	119	V-i-a, V-s-r	112	3	179
II. A.[15]	Vm, V-i-r, V-s, of situation	101.4	4	39	Vm	104.4	1	52
II. B.	Vm, V-i-a & V-i-r, at places	147.6	8	39	Vm	92	3	58
II. C.	Vm, Grm-s-r	103.8	2	10	V-i-a, V-i-r	92.5	1	37
III. A.[16]	Vm	168	14	44	Vm, V-i-a	160	9	95
III. B.	Vm	155	16	70	V-i-a, Vm	127.5	9	73
III. C.	Vm	158	8	70	V-i-a, V-i-r	106	2	49
IV. A.[17]	Vm	163	11	86	V-i-a, Vm	103+	1	146
IV. B.	Vm	178	10	120	Vm, at places	109.7	1	153
IV. C.					V-i-a, Vm	120.4	2	158

[14] Counting aloud.

[15] Reading mentally.

[16] Reading aloud.

[17] Counting aloud, blindfolded.

[18] A, attention undirected; B, attention on distracting process; C, attention on writing. A, auditory; V, visual; Grm, grapho-motor; Avm, auditory-vocal-motor; Vm, vocal-motor; i, ideational; r, report; a, anticipatory; s, sensational.

4. General Conclusion with Discussion and Comparison of Results from Different Subjects.

(Tables IV and V.)

The main difference brought out by a comparison of the records of the different subjects is the varying extent to which writing is automatized. Much grapho-motor automatism was evident in the work of B, R and H; little in that of A, S, D and Y. In the case of the first three, *attention* went normally to the *distracting* process; in the case of the last four, *attention* went normally to *writing*. B and H reported a strong tendency to write the words they were reading; A and D, a tendency to articulate aloud the words they were writing.

(*a*) The whole course of the experiment goes to show that *attention* is concentrated on the *least automatic* process.[19] The focusing of attention on writing, means for B, H and R an intensification of some form of *anticipatory* cue; for D, A, Y and S, usually, concentration on *report* from writing either in its kinæsthetic or visual form. The evidence for such conclusion is thoroughly adequate, although failure to follow instructions in giving attention to the required process sometimes occurred.

A review of the methods employed by each subject in enforcing writing-consciousness will emphasize the conclusion. B resorted usually to some form of auditory or vocal intensification. He either emphasized the auditory aspect of vocal cue or listened to the sound made by the pen; or else doubled or retarded the vocal cue.[20] H concentrated on the visual side of the situation when articulation was used as a distraction, even resorting, when writing blindfolded, to the laborious and, for her, exceedingly difficult method of visual anticipation. When visual distraction was used she made use of more than the usual number of vocal-motor cues. R attempted at different times various methods of enforcing the writing-consciousness; retarding and emphasizing the auditory-vocal-motor

[19] See Angell and Moore: 'Reaction-Time: A Study in Attention and Habit,' *Psychol. Rev.*, III., p. 245.

[20] Then were times, even, when B suspected that the slow auditory-vocal-process was following, not preceding, the rapid hand movement.

process, and resorting to visual anticipation in places. In one case (IV C) R concentrated on the kinæsthetic report, which was found to retard writing, a result which should be compared with the disorganization of writing resulting for B when attention went to kinæsthetic or visual report from writing.

D found that concentration on visual report or on contact sensations were effectual methods of keeping attention on writing. A concentrated on hand-kinæsthetic or visual report. S concentrated on writing by an increase in the amount of visual material, both anticipatory and report. The writing process for S is well organized and at times the attention seems concentrated on the *anticipatory* rather than the *report* side of the situation. Y in attending to writing often gave actual attention to the formation of separate letters. Withdrawal of attention from writing results in motor disorganization, so little is the process automatized. Even to write his own name well, requires careful supervision. Of all the subjects, Y showed least automatizing of writing process; D, after Y, showed least automatization. For both S and A there is need of less supervision.

It follows from the conclusion above that the most effective distractions are those which appeal to the least automatic processes; for B, auditory and visual; for H, visual; for R, visual. More or less complete distraction with these subjects tends to render writing more automatic and more rapid. Of the other subjects, articulatory distraction is more effective for S and Y and, probably, visual for A and D. In the case of the latter a visual distraction is far from being complete. More or less complete distraction for the last four subjects tends to inhibit writing, as Y's records show time and again, and as was evident when D attempted to write while performing mental arithmetic.

It is evident that success in meeting the conditions of the test does not depend, except to a very slight extent, upon versatility in the use of various imagery processes nor upon skill in 'shunting' these processes, although such 'shunting' occurs at times. (D, for instance, in I and IV made less use of vocal-motor process than in II and III; H in I and IV had

recourse to visual imagery, etc.) General habits of attention were much more potent in facilitating or retarding operations. Such general habits as ability to oscillate attention rapidly (R and A) or power to diffuse attention over a double process, with intense concentration (D), or slowness or inertia in oscillation, are potent in determining results. Still more influential, however, is the tendency to focus by way of certain processes, so that success is more often achieved by a synchronization or oscillatory conflict of two similar processes having high attentional value, than by 'shunting' so as to avoid imagery conflict. In this way B drives abreast two auditory or vocal processes and S, A and D two visual processes.

(*b*) *Mental Imagery.* — Auditory-vocal-motor or vocal-motor imagery as the main anticipatory writing-control was evident in the case of every subject, although its value was reduced under certain conditions (see S, I). The auditory aspect of this process was pronounced for B, R, A and D and at times these subjects reported purely auditory imagery. The ability to emphasize and, perhaps, to dissociate the auditory aspect of the vocal process from the articulatory expert gave these subjects, at times, an advantage over H, Y and S, all of whom are deficient in auditory control.

The verbal unit as reported by A, B and R was, clearly, the line or phrase. A reduction of this unit to word or even letter, perhaps in consequence of inability to utilize auditory images, increased Y's difficulties. Probably, however, the reduction of the verbal unit is due to innervation difficulties.

Much visual material was evident in the results as reported by A, D, Y and S, for all of whom there is need of visual control, either sensational or ideational. B, R and H have recourse to visual control only occasionally.

Dependence upon grapho-motor anticipation was very slight. Conscious dependence upon grapho-motor report, either visual or kinæsthetic, was particularly evident in the case of D and Y, less so in the case of A and S. Automatic dependence upon grapho-motor control was very marked for B, R and H.

In general, the experiments of Part II bring out the functional value of the different writing 'controls' instead of test-

ing, as was expected, the possibility of different controls by the elimination of one control and consequent 'shunting' to another. Distraction does not eliminate a particular form of imagery, although it often introduces conflicts with it and thus throws it into the foreground; chiefly, however, it tests the tendency to concentrate attention on a particular point in the situation and so indirectly determines the attentional value of different 'controls.'

(*c*) *Lapses.*—Errors occurring in writing are evidences of the lapses or anticipations of attention. It is instructive that many lapses occur in the writing of B (86);[21] in that of H (95); and in that of Y (80). On the other hand, there are few in the writing of D (27); in that of A (38); in that of R (39); and of S (34). Ranking the subjects by reference to number of lapses occurring, and beginning with the subject who gave the fewest, we get the following grouping: D, S, A, R, B, Y, H. It is obvious that the subjects for whom writing was most automatic were more subject to lapses, particularly lapses of a repetitionary character.

B, who furnished an excellent introspective account of the cause of certain lapses occurring in his own writing, reported that lapses which are repetitionary in nature (persistence lapses in Bawden's phraseology)[22] were due to lapses of kinæsthetic report from the hand with a return of attention to writing and consequent repetition of letters or words of which there had been no report. Bawden's explanation of persistence lapses as due to habit is similar.[23] In the case of what may be termed 'graphic stuttering,' or persistent repetition of letter-part or word-part, the automatic character of the process is still further in evidence. The writer is inclined to cite such cases of repetition as due to a self-suggested movement comparable to cases of suggestion where the movement of hand is externally impressed and automatically continued. Evidence of such continued repetition occurs in the writing of H, Y and B.

[21] Only the lapses that occurred in writing the verse are included in this numbering. Such an estimation is made in order to make results comparable. Cases where records are slightly incomplete (A, Y and H) would probably yield a slightly greater number of lapses if the tests omitted should be supplied.

[22] Bawden, 'A Study of Lapses.'

[23] *Op. cit.*, p. 89 f.

The fact that 55 per cent. of the whole number of errors made by B were repetitionary in character taken in connection with the fact that only 21 per cent. of A's lapses were of such character furnishes interesting confirmation of the conclusion that such lapses represent errors arising from the lapse of motor consciousness and originate from breaks in the functioning of an automatic process.

It should be noticed, however, that errors of omission (ellipsis, in Bawden's terminology) are ambiguous, since an omission may be due either (1) to a sense of having written a letter or letter-part on account of its graphic similarity to a movement just made, or (2) to inaccuracy of grapho-motor control, or (3) to attentional anticipation.

Lapses of omission or of repetition constitute the majority of the errors recorded. There occur, however, some intrusions from reading and, occasionally, an exchange of letter-parts, a splitting of a letter so that while eventually it is completely made, it is not made in sequence. The latter lapse is evidently purely motor in origin.

(*d*) The study of the lapses occurring in the writing tests leads naturally to a brief discussion of the meaning of automatism so far as brought out in the experiments under consideration. It is evident that in proportion as distraction tended to be complete, writing control and movement became marginal (less and less distinct) with approach to *automatic writing* as a limit. Such automatism might extend over a letter, part or whole, a word, a phrase or even several lines. The analysis of the data so obtained is of particular interest in the light of recent discussions anent the status of the so-called 'subconscious.'

The bearing upon the point in controversy, namely the merely physiological or psycho-physiological character of automatic writing, is shown by the fact that it occurs most frequently in the subjects who are shown by other tests to be particularly grapho-motor in type. In their case motor organization of the writing habit has been successful to a high degree. Accepting a physiological explanation of automatic-writing, the correlation just mentioned is natural enough; but under the supposition of a detached 'co-consciousness,' it is not clear why

a grapho-motor control should eventuate in automatic writing more frequently than does a visual control, for instance. Nor, again, why automatism should be achieved most frequently in the case of the most habitually written phrases, such for instance as the name of the writer.

It is, of course, quite possible for the advocates of the detached consciousness hypothesis to urge that the experiments just discussed are beside the point, since the constant writing of the test-verse favored the production of a writing-habit, which could indeed be explained in physiological terms; but that the interpretation of those cases of automatic writing, which issue in such novel and meaningful combinations of words as is held to be explicable only by the presence of a selective consciousness, remains unaltered. The writer readily concedes the limited application of the experiments here recorded. Yet the transition from marginal awareness to complete unawareness of writing; the long lapses of writing-consciousness that occurred rarely; the dropping out at various times of anticipatory, report, or memory processes; the occasional loss of a sense of agency bear such close analogy to descriptive accounts of what takes place in automatic writing so-called, that it is difficult to believe that they are products of wholly different conditions. To the writer, a physiological interpretation of the present test, at least, is the only one that has meaning.

To repeat, it is instructive to notice the four forms that lapse of writing consciousness might assume, namely, lapse of memory, lapse of report, lapse of anticipation, or lapse of anticipation and report.[24]

First of all, the memory lapse. In tests that were emotionally disturbing, the reagent often confessed his inability to recall the nature of the writing control, although confident of some sort of anticipatory or ' report ' cue. The evanescent character of many images when recalled retrospectively was often commented upon. The fleeting character of the image was described metaphorically by speaking of it as a ' flash ' or a ' flicker ' or comparing it to a ' fish-like darting in and out

[24] Cf. Jastrow: *The Subconscious,* p. 450 f.

of the stream of consciousness.'[25] At other times the subject simply said 'I've forgotten.'

The possibility of such memory lapses, throws, of course, suspicion upon those instances in which the reagent rather confidently reported that he had no knowledge of what he had written, this suspicion being particularly cogent in the case of the longer tests where the introspective account was delayed somewhat. That all failures to report awareness of the writing were not due to memory lapses, may, however, be concluded from the following facts, cited already in another connection: (1) Errors occur such as are easily explicable as due to lapse of awareness, for instance the repetition of words or letters through lapsing of the kinæsthetic or other report of the movement. (2) There is a change in the appearance and size of the writing as it approaches automatism. (3) The lapse of awareness of some particular 'control' process, usually present, gives a peculiar quality to consciousness, the cause of which may be determined by a process of elimination.

Granting that not all lapses of consciousness are due to lapses of memory, one still needs to distinguish lapse of anticipation of movement from lapse of report of movement made. In general, the course of the experiments has tended to establish the very great value of 'report' processes, both kinæsthetic and visual, in control of movement, so that in a way the distinction is a false one for all 'report' processes may in fact be also 'anticipatory' so far as they constitute the cue for the ensuing movement. In such a case, then, the distinction has only descriptive value. But the distinction has, also, functional value; for writing remains voluntary even though there be more or less of a lapse of report; on the other hand, in proportion as the words written are reported but not anticipated, writing remains conscious but becomes non-voluntary.

In ordinary writing there is usually both anticipation, chiefly of a vocal-motor type, and also a report; but with growing automatism of movement, 'report' processes become marginal except in case of conflict. Probably a lapse of 'report,' to a

[25] And the 'psychological angling' for such 'cues' demands much practice and alertness.

greater or less extent, is most frequent in writing on topics that demand concentration on the meaning to be conveyed, for in such cases interest is on the anticipatory side and not at all on the expressive.[26] Such a lapse of report from consciousness may be carried to a great extent without impairing the sense of agency. If, however, the topic written upon encourages the use of habitual sequences of words, there may be frequent lapse of anticipatory cues, except those of kinæsthetic or visual report. Such a reduction of anticipatory content would probably occur somewhat frequently in the case of one for whom mental articulation is well automatized, and would be accompanied by loss of the feeling of agency, though the writer would remain conscious of his movements. Such cases of automatic writing (cited frequently in the literature of the subject) represent approach to automatism from the anticipatory side; such automatism could probably be induced in D and A among the subjects of the present test. Reagents such as B and R, with whom there is normally less consciousness of movement, with lapse of anticipation would lose all consciousness of writing and furnish examples of the true automatic writing, so-called in the literature of the subject.

Habit, automatism, the physiological, represents the final limit of the psychical. Completely achieved automatism is physiological and motor; but imperfectly achieved automatism retains the character of all consciousness and is sensory in character. The approximation to automatism (minimum of awareness, waning of attention) may occur on the visual or auditory side as well as on the kinæsthetic. For the writer, the visual-auditory flash of the initial letter of her name that came, right or wrong, in response to the signal in the tests of Part III, was as automatic as the jerk of H's hand in penning the first stroke of her name. In both cases conflict or retardation of response brought the ' cue ' or ' report ' to the focus of consciousness.

A comparison of the rapidity with which writing went on

[26] Compare, for instance, your penmanship in a formal application for some social favor, with the dishabille in which it appears in your jotting down of your latest inspiration! The chirographic result of much preoccupation with weighty matters gives color perhaps to the charitable maxim that makes poor penmanship a characteristic of ' genius.'

under distraction, if the records are taken as a whole and test V omitted, results in the following ranking: D, R, A, B, H, S, Y. Rapid writing in such experiments was mediated more successfully by automatism on the side of the distracting process than by partial writing automatism; for in the latter case the alternate lapse and return of attention to writing caused disturbances. Complete surrender to the writing automatism gave, however, low time-readings for B (in II and V), R and H. This surrender occurred more frequently in the case of R than in the case of B. For the latter, supervision is withdrawn from writing only when distraction is complete; but when this happens B's rapidity increases greatly. The fact that both counting and reading were automatic processes for D explains the rapidity with which she wrote under distraction. The intense concentration demanded and the excitement of the experiment served several times (see record for name) to induce a writing rapidity greater than could be achieved under normal conditions. The high value of counting and reading as distracting processes, articulation being particularly distracting, explains the difficulties of Y and S in meeting the test and their slow progress in writing. Unpleasant emotional disturbances were, however, much more noticeable in the case of Y and he reported actual conflict of hand and vocal innervation. A test in which Y wrote a series of autographs while doing work in mental arithmetic, the results of which he announced orally, showed that in no case did writing go on while Y was articulating. The results of the mental operations were announced during pauses in the writing, although Y reported that, visually, he was aware of the result even while unable to articulate it.

To a certain extent the table shows that an increase in time of writing is found when attention goes to writing in the case of H, B and R; with a decrease for A and D. This is what one would expect from the general course of the experiments.

5. Distraction Experiments. Writing of Name.

In addition to the experiments in which the subject wrote the test-verse under distraction, a second series was tried under

exactly similar conditions, in which the writing of the subject's name and the phrase, 'University of Chicago' was substituted for writing the verse. As the writing of the phrase gave results that differed only incidentally from those obtained when the name was written, no report will be made upon it; but a detailed analysis will be made of the test on writing the name.

In planning the experiment, it was thought that the writing of the name, being so habitual an act, would give results somewhat different from those obtained when the verse was used in the test. To a certain extent this was found to be true in that the name was more frequently written automatically than was the verse. Certain observers, however, for whom the verse-test had shown writing to be a highly conscious act, rarely wrote even their own name without conscious supervision. On the whole, the results obtained from the test in writing the name are closely comparable with those obtained when the verse was written. The results for this series are tabulated[27] for each subject, and each table is accompanied by a general descriptive summary.

The results from the test on the verse made it evident that certain characteristic changes in the amplitude of the writing movement resulted when writing was modified through the presence of a distracting process or because of changed conditions of attention. In order to get a quantitative statement of this change in the case of every subject, measurements were made of the height of chosen letters[28] in the written name and also of the breadth of all letters taken together, the latter measurement being obtained by getting the horizontal extension of the name as a whole. In order to have some statement of the normal variation in the size of the characters that might be expected during any hour, one experimental session was given to obtaining a series of fifty autographs written under normal conditions. To avoid fatigue, between the writing of every

[27] The abbreviations used in these tables are the same as those employed in Tables IV. and V., viz., A, auditory; V, visual; Avm, auditory-vocal-motor; Vm, vocal-motor; Grm, grapho-motor; i, ideational; s, sensational; a, anticipatory; r, report.

[28] These measurements were taken along the slant of the letter. Characteristic letters were selected for measurement such as capitals and long letters like 'y.'

ten autographs a rest-interval of five minutes was given. From this series the M.V. is calculated. The amount of departure from the normal mean variation in respect either to speed or amplitude of writing may be easily seen by comparing the normal given for any test with the result obtained when there was distraction.[29] For convenience of comparison these normal averages for every subject are listed just above the tabulated statement of the results obtained in the series in which the name was written under the test conditions.

A further test, not tried with the verse, was carried on in connection with writing the name. In this test the experimenter, at the moment that he gave the reagent the signal to begin writing, gave also a number in the hundreds to which the subject added successively 9, 8, 7, 6, 5 and announced the results of the successive additions aloud, all the while writing his name continuously, one autograph below the other. Two series were tried under these conditions; in the first, the subject had his eyes open; in the second, he was blindfolded. The results from these experiments are not included in the tables but are given in the summarizing statement at the close of each table.

Descriptive Summary (*B*).—Unless directed to attend to writing, B usually wrote his name more or less automatically. When attention went to the writing of the name, in contrast to what happened in writing the verse, little use was made of auditory-vocal-motor enforcement. Instead, attention went to the actual movements of the hand or to the visual report, with a consequent break-up of the coördination. The most successful method of enforcement was to concentrate on the *sound* of the moving pen.

The rapidity with which the name was written approximated or was above the normal rapidity unless attention was forced to the grapho-motor or visual report from writing, a form of attention which retarded writing. Many lapses occur in writing the name; the series shows twelve (12).

[29] The measurements given in the table represent one trial each. When dates are given in the notes, the test was *not* completely carried out on one day and in such a case more than one normal is recorded. In every instance the variation from the normal taken the same day is the important thing to observe.

TABLE VI.

WRITING OF NAME—NORMAL CONDITIONS. SUBJECT B.

Average 50 trials, one sitting.

Rapidity, 4.694s.; M.V., .24568s. (Marked R. in table below.)

Length in horiontal, while name, 89.32 mm.; M.V., 7.95 mm. (Marked L-h. in table.)

Height of capitals (4), 8.8 mm.; M.V., .717 mm. (Marked H.C. in table.)

Length in vertical, long letters, 11.55 mm.; M.V., .814 mm. (Marked L-v. in table.)

Height small letters, 1.232 mm.; M.V., .156 mm. (Marked H.S. in table.)

Name—Distraction Experiments.

	R.	Lapses.	No. Counted or Read.	All Measurements in mm.				Control Processes.
				L-h.	H.C.	L-v.	H.S.	
Normal	5	0		76	10	13	1.5	
I.[30] A.	5	0	16	70	9.4	11.5	1.6	Grapho-motor control. Ignored visual perception.
I. B.	5.3	3	20	85	7.7	11	2.1	Automatic, but grapho-motor control strong. Vr ignored.
I. C.	5.4	0	20	94	13	11	1.6	Attention on writing breaks up coördination.
I. C.	7	0		92	15	13.5	1.8	
Normal	5.2	0		68	9.8	14	1.4	
II.[31] A.	4.6	1	5	78	11.3	11.2	3.7	Automatic. Slight Grm-r. and Ar from pen at places.
II. B.	5	3	12	86	10.6	9	2.5	Automatic. Blurred report.
II. C.	7.6	0	3	98	10.5	12	3	Attention on Grm-r and Ar from pen.
Normal	5.2			77	13	15	1.7	
III.[32] A.	7.7	1	6	88	13.2	14	4.2	Cue Avm & Grm-r & Vr. Attention on writing at places.
III. B.	6.4	0	11	110	13.4	13	3.2	No report on capitals. Grm-r at close.
III. C.	10.3	2		116	14.3	20	4.3	Forced attention on Vr. Strained.
III. C.	5.2	0		94	13.2	14	3.3	Attention on sound of writing. Ar.
III. C.	7.4	0		104	17.6	15	5	Attention not on name for capitals; toward close, visual report.
Normal	5.2	0		74	13.6	16	1.6	
IV.[33] A.	5	2	16	93	14.3	14	3.3	Lapse of Grm-r at places. Counting and writing, automatic.
IV. B.	4.4	1	20	82	15.2	13.5	4.4	Cues and report evanescent.
IV. C.	5.5	0	15	110	16	18	3.4	Attention on w. strong. V & Grm-r for capitals.

[30] I. counting aloud and writing. A, attention undirected; B, attention on distracting process; C, attention on writing.

[31] II. reading mentally and writing. A, B, C (see note 30).

[32] III. reading aloud and writing. A, B, C (see note 30).

[33] IV. counting aloud and writing, blindfolded. A, B, C (see note 30).

Distraction, in every case but one (I A), caused a great increase in the horizontal amplitude of the writing, and, usually, an increase in the vertical extent also. This increase was evident whether the writing was automatic or attention focused, by whatever method, on the writing. The one-space letters show the greatest increase in height. See Plate III, 1 (*a*), 1 (*b*).

Mental Addition Test.—For B the mental additions were not difficult and toward the close of the second series (eyes blindfolded) the additions required no effort of attention whatever. Consequently distraction was not complete and there was much oscillation of attention.

Auditory-vocal-motor imagery was used for the work in addition with occasional recourse to visual imagery. When the eyes were open, the writing was controlled visually. When B was blindfolded and attention went to writing, it focused on anticipatory grapho-motor images or on the grapho-motor report. The alternate fixation and lapse of attention resulted in the errors of repetition and exchange of letter-strokes which B's previous writing under distraction had shown. Similarity in the letter-parts of the first initials (W and V) often gave an ambiguity in the grapho-motor report which B remarked upon.

The signatures in both the tests, but particularly in the latter (eyes blindfolded), were written in a large free hand with considerable pressure on pen. B reported an increase in automatism toward close of series and the last autograph covered, horizontally, 144 mm.; the one-space letters averaged 5.5 mm.; the capitals, 15.5 mm., a very great magnification of writing. Compare Plate III, 7 (*b*).

Descriptive Summary (*D*).—The writing of the name was much more automatic than the writing of the verse. When conditions required it, attention was focused on writing the name, as on writing the verse, by concentration on the visual report.

With distraction there was usually a quickening of speed, sometimes to a very noticeable extent. In II and III, when a visual ideational series was run tandem with a visual sensational series, there was a decrease in rapidity.

TABLE VII.

WRITING OF NAME, NORMAL CONDITIONS. SUBJECT D.

Averages made from 50 trials, one sitting.

Rapidity, 5.566s.; M.V., .16016s. (Marked R. in table.)

Length in horizontal, whole name, 44.37 mm.; M.V., 2.734 mm. (Marked L-h. in table.)

Length of vertical, initial 'J,' 27.47 mm.; M.V., 1.0912 mm. (Marked L-v. in table.)

Height of other capitals (2), 6.29 mm.; M.V., .576 mm. (Marked H.C. in table.)

Height of one space letters (7), 1.039 mm.; M.V., .1636 mm. (Marked H.S. in table.)

Writing of Name—Distraction Experiments.

	R.	No. of Lapses.	No. Counted or Read.	Measurements in mm.				Control Processes.
				L-h.	L-v.	H.C.	H.S.	
Normal	5.4	0		55	25	7	1.11	
I.[34] A.	5	1	23	50	16	4	.95	Initial cue, contact with paper; counting- and writing-rhythm synchronized.
I. A.	4.2	0	20	40	16	5	1.35	Initial cue, contact, followed by A-i-a.
I. B.	4.8	0	15	42	16	7.2	1.12	Initial cue, contact; heavy pressure on pen; hard to focus counting.
I. C.	4.6	0	21	36	13	4.2	.9	Attention focused on visual report.
Normal[38]	5.3			43	18	7.5	1.07	
Normal[39]	6			61	17	7.2	1	
II.[35] A.[38]	4.8	0	7	53	14	5.2	1.14	Initial Vm cue, a mental mumble; lapse of grapho-motor report; light pressure.
II.[38] B.	5	0	8	55	19	4.2	1.38	Initial V-i-a cue. After that, automatic.
II.[39] B.	5	0	10	40	16	5	1.5	No initial cue but signal. Slight consciousness of Gr.-motor report.
II.[39] C.	8.4	0	11	39	14	4.5	1.18	Avm cue with V-i-r, letter by letter. For one capital a fusion of A. and V. imagery.[40]
Normal	5.4			49	20.5	6.5	.83	Avm cue with A-s-r.
III.[36] A.	5	0	12	48	15.5	6	1.44	No initial cue. Hand 'set' before signal. Writing automatic. Light pressure.
III. B.	6	0	12	31	16.5	3.5	1.11	After initial cue, automatic. Heavy pressure.
III. C.	6.8	0	6	40	12	4	1.1	Avm cue with V-i-r. Heavy pressure.
Normal	5.4			69	21	9.5	.93	
IV.[37] A.	3.9	1		38	10.5	4	1.31	Initial cue V-i-a of 'J.'
IV. B.	5	0	9	36.5	13	4.2	1.35	Counting and writing rhythm synchronized.
IV. B.	4.9	0	9	36	14	4	1.12	Initial cue, a visualized 'l.' Heavy pressure.
IV. C.	4.4	0	15	32	12	4.5	1	V-i-r. Head bent low over writing.
IV. C.	4.2	0	17	29	9	3.2	1	V-i-r; pressure heavy; faint Avm.

[34] I. counting aloud and writing, eyes open. A, attention undirected; B, attention on distracting process; C, attention on writing.

[35] II. reading mentally and writing. A, B, C (see note 34).
[36] III. reading aloud and writing. A, B, C (see note 34).
[37] IV. counting aloud and writing, blindfolded. A, B, C (see note 34).
[38] January 17.
[39] January 24.
[40] This initial, an 'E,' 'sounds as it looks.'

In the whole series but two (2) lapses are recorded.

There was a very great decrease in amplitude of the writing movement both horizontal and vertical in I and IV (articulatory distraction), especially when attention was concentrated on writing. In II A and B, there was an increase in the horizontal movement. Under these conditions distraction was more complete and writing more automatic. The notes, here, are instructive, for D spoke of the lapse of consciousness of the formation of letters and reported awareness only of general direction of hand-movement. It was as though the hand were drawing a straight line outward. (Cf. test below where mental arithmetic was used as a distraction.) See Plate III, 2 (*a*), 2 (*b*).

Mental Addition Test.—D found this experiment an exceedingly difficult and fatiguing one. It was highly disagreeable. Mental addition requires great effort of attention on D's part so that such mental work is a very effective method of distraction for her. With the eyes open the writing remained under *visual perceptual* control, was done *consciously,* and resulted in a *minute even* writing, showing heavy *pressure* on the pen. The average time required for writing the name was about two (2) seconds *above the normal,* a great retardation of speed. There was some tendency to visualize numbers, a visualization which the presence of the writing confused.

When D was blindfolded, the withdrawal of the visual perception of the result, and the blurring of the visual ideational report through the tendency to visualize the numbers resulted in the *withdrawal* of *attention* from writing to a greater degree than in any other experiment. At certain places there was complete lapse of consciousness of the writing of certain letters. The writing was somewhat disorganized and considerably *increased* in horizontal *extent.* The one-space letters were also increased in vertical as well as horizontal extent. The autographs were written *more rapidly* than when the eyes were open and there was much *less pressure* on the pen.

TABLE VIII.

WRITING OF NAME, NORMAL CONDITIONS. SUBJECT S.

Averages made from 50 trials, one sitting.

Rapidity, 7.9998s.; M.V., .1082848. (Marked R. in table.)

Length in horizontal, whole name, 89.1 mm.; M.V., 3.9 mm. (Marked L-h. in table.)

Height of initial capital, 6.03 mm.; M.V., .7056 mm. (Marked H.C. in table.)

Height of other capitals (2) averaged, 8.62 mm.; M.V., .576 mm. (Marked H.c. in table.)

Height of final 'd,' 11.04 mm.; M.V., 1.31 mm. (Marked H.d. in table.)

Writing of Name—Distraction Experiments.

	R.	No. of Lapses.	No. Counted or Read.	Measurements in mm.				Control Processes.
				L.h.	H.C.	H.c.	Hd.	
Normal	7.6	0		87	10	10.5	13	
I.[41] A.	8.4	0	29	87	9	9.5	13	Initial V-i-a cue.
I. B.	7.4	0	29	95	7	8.5	13	Initial V-i-a cue. At close slight grapho-motor consciousness.
I. C.	10.3	0	28	87	9	8	9	Initial V-i-a cue. Visual attention.
Normal	8	0		92	8	9.5	12	
II.[42] A.	7.4	0	19	87	8	7	9	Initial V-i-a cue; slight Vm; conscious of grapho-motor report.
II. B.	8.6	1	10	92	8	7.5	8	Initial V-i-a cue. Vm, letter by letter. Attention on writing.
II. C.	9	0	7	72.5	5	6.5	9	V-i-a at intervals; Vm, letter by letter. Conscious of grapho-motor report. Hard pressure on pen.
Normal	8.2	0		98	6	9.5	11	
III.[43] A.	10.9	1	14	99[45]	8	8.2	8	Initial V-i-a cue; then conscious grapho-motor control, both a and r.
III. B.	9	1	12	95[45]	7	7.5	7.5	Initial V-i-a; then Grm-i-a.
C.	10.3	1	10	91	6	9	9	V-i-a at intervals; V-i-r, three times, including all that had been written at moment of report.
Normal	7.6	0		92	8	10	11.5	
IV.[44] A.	8.8	0	24	102	10	11	6	V-i-a throughout.
IV. B.	7.2	0	24	101	8	9	9	Initial V-i-a; rest automatic.
IV. C.	8.3	0	24	92	7.5	8	5	V-i-a and V-i-r,[46] this report was for every letter, a report on the formation of letters.

[41] I. counting aloud and writing, eyes open. A, attention undirected; B, attention on distracting process; C, attention on writing.

[42] II. reading mentally and writing. A, B, C (see note 41).

[43] III. reading aloud and writing. A, B, C (see note 41).

[44] IV. counting aloud and writing, blindfolded. A, B, C (see note 41).

[45] Length increased by repetition.

[46] The visual cue was seen above the paper; the visual report followed in the wake of the pen, flowed with the ink.

Descriptive Summary (*S*).—S used a great deal of visual material in writing his name just as he did in writing the verse. This visual material took both anticipatory and 'report' form. In only one or two cases was there an approach to automatism. Attention went naturally to writing. Enforcement of attention to writing was brought about by an increased use of visual material, usually in the form of a visual report.

With distraction there was usually a retardation in the speed of writing. The notes on the three exceptions to this statement show, on these occasions, a tendency toward increased automatism.

A few lapses occurred in this series; three (3) in all.

S's writing under distraction shows a slight but pretty consistent reduction in size of writing characters. One or two exceptions to this statement occur, but in such cases there was usually evidence of slight approximation to automatism. Without exception, attention on the writing caused considerable reduction in writing amplitude.

Mental Addition Test.—S found it impossible to write while carrying on a successive addition of 9, 8, 7, 6, 5. Four trials were made, with the eyes open in every case, but each time the mental addition inhibited the writing movement. A simpler addition consisting of adding by 7's was then substituted for the more difficult one. The visual perception of the writing proved, however, so distracting that S was obliged to look off the paper in order to add the numbers, which were visualized. When attention returned to writing, S looked down at the paper and made use of a visual cue. There was much oscillation of attention, and very little surrender to writing automatism. There was a slight decrease in the size of the writing characters, except for the one-space letters, increased pressure on pen, and very great retardation of writing-speed.

Descriptive Summary (*Y*).—Y found it very difficult to write even his own name under distraction. Visual, graphomotor, and vocal-motor processes were all utilized in the attempt to maintain writing. Writing under distraction became much more vertical than Y's normal writing and much less finished.

TABLE IX.

WRITING OF NAME, NORMAL CONDITIONS. SUBJECT Y.

Averages made from 50 trials, one sitting.

Rapidity, 3.94s.; M.V., .1112s. (Marked R. in table.)

Length in horizontal, whole name, 51.94 mm.; M.V., 2.98 mm. (Marked L-h. in table.)

Height of initial capitals (2), 8.296 mm.; M.V., .617 mm. (Marked H.C. in table.)

Length in vertical, initial 'Y,' 18.47 mm.; M.V., 1.1344 mm. (Marked L-v. in table.)

Height one space letters, 1.729 mm.; M.V., .201 mm. (Marked H.S. in table.)

Writing of Name—Distraction Experiments.

	R.	No. of Lapses.	No. Counted or Read.	Measurements in mm.				Control Processes.
				L-h.	H.C.	L-v	H.S.	
Normal[51]	4	0		78	10.2	20	1.35	
Normal[52]	4	0		58.5	8.7	19.5	2	
I.[47] A.[51]	5.6	1	16	60	7.7	17	1.37	Introspection baffled.
I. B.[52]	9.4	0	11	51	7.5	12.5	2	Attention on finger movement and some V attention. Counted three before beginning to write.
I. C.[52]	6.7	0	12	58	7.7	15	2.2	Anticipatory Grm cue at start.
Normal[53]	3.8	0		68.5	11.5	22	1.27	
Normal[54]	4.2			61	9.5	19	1.35	
II.[48] A.[53]	4.8	2	9	73	9.5	17	1.93	Vm. V-i-r at close. Oscillation of attention, but attention chiefly on writing.
II. B.[53]	6.2	2	2	66	9.5	17	1.64	V-i-a at start. Vm report. Oscillation of attention.
II. C.[54]	6.9	1		55	9.5	20.5	2.2	Attention on finger movement and V-i-r. Vm, letter by letter. Heavy pressure on pen. Oscillation of attention but no conflict of processes.
Normal[55]	4.4	0		60	12.2	21.5	1.42	Vm at intervals.
Normal[56]	4	0		63	10.2	23	1.78	
III.[49] A.[56]	4.6	0	4	75	10.2	19	2	No oscillation of attention. Superimposition[57] of Vm (throat), letter by letter cue for writing, with V-i-r, and Vm (lip) imagery for writing.
III. B.[55]	7.4	2	7	82	11.5	20	2.18	Vm at places. V-i-r at places. Conscious of grapho-motor report.
III. B.[56]	12.8	2[58]	12	78	8.7	18	1.6	V-i-r series as cue. Difficult.
III. C.	No test							
Normal	4			63	10	21	1.42	
IV.[50] A.	6	1	13	60	8.2	1.8	2.71	Vm, letter by letter. V-i-a at places. Pressure heavy. Oscillation of attention.
IV. B.	6.2	2	10	66	12	22	2.57	V-i-a; incipient impulse to pronounce. Pressure heavy. Counted three before starting to write.
IV. C.	No test							

[47] I. counting aloud and writing, eyes open. A, attention undirected; B, attention on distracting process; C, attention on writing.

[48] II. reading mentally and writing. A, B, C (see note 47).

[49] III. reading aloud and writing. A, B, C (see note 47).

[50] IV. counting aloud and writing, blindfolded. A, B, C (see note 47).

[51] January 22.

[52] January 29.

[53] February 6.

[54] February 13.

[55] February 20.

[56] February 27, Y. was tired at time of test.

[57] A novel experience for Y.

[58] At close of name there was graphic stuttering. Throughout, writing is nervous.

The writing-rapidity was greatly retarded by distraction.

Lapses occurred in the writing of nearly every autograph when distraction was present. The series shows, in all, thirteen lapses (13). In order to write well, Y reports that care is needed and a certain amount of visual control. Plate 5 (*a*), 5 (*b*).

With distraction there was a reduction in writing-amplitude (except for the one-space letters) in all cases but III A and B, IV B and, in horizontal extent, II A. The increase in the height of the one-space letters was noticeable throughout.

Mental Addition Test.—Y found the mental calculations involved in the additions easy and not at all fatiguing. Although vocal-motor associations were utilized in adding he showed considerable facility in visualization, a method which was used to hold the sums resulting from the addition. For instance, if he had lost, through distraction of attention, the number that was next to be added in the series, he could recall the visualized results of the additions and so calculate the next number to be added in the series. He was able to review results back four or five steps.

For writing his name Y used mental vocalization, letter by letter. To write at all required conscious supervision and it was not possible for Y to write while announcing aloud the results of his calculation. At times, he reported that he was aware of the result of his addition but could not enunciate it without inhibiting writing. Without giving very careful attention, involving usually numerical calculation, Y found it impossible to write correctly the closing strokes of his name (um).

In one place, eyes open, where Y made an unsuccessful effort to add while writing, the resulting signature shows distinctly the effect of inhibition. The initial capital is reduced from the six or nine millimeters of the normal autograph to barely three millimeters. When the eyes were closed inhibition in extent of movement was even more evident than when eyes were open; writing was more frequently disorganized; and there was heavier pressure upon the pen. Plate III, 7 (*a*).

Descriptive Summary (*R*).—The writing of the name was a highly automatized act for R. To focus attention on it required visual or auditory-vocal-motor enforcement.

With distraction there was usually a quickening of speed. This quickening was least noticeable when attention was on the writing. Only two lapses are recorded in the series of tests on the name.

Throughout the experiments there was a very great increase in the height of the one-space letters. The normal mean variation in the length of the name as a whole is so great that only the tests in IV and in I B and III C show an increase in horizontal amplitude above the normal mean variation. In IV, however, this increase is very great. There is little tendency towards increased height of the capital letters, in fact, in several cases there is a decrease. This is probably due to the fact that R consciously begins her name with a big 'flourishing' capital. Plate III, 3 (*a*), 3 (*b*).

Mental Addition Test.—The test requiring successive mental addition of 9, 8, 7, 6, 5 to the given number, eyes open, R found very difficult. There was no lapse of consciousness of writing name while performing the work, which was done by mental vocal-motor processes. The writing of name was well done, somewhat smaller than usual, and greatly retarded in speed. Simpler work in addition was substituted and the test repeated, another day. On this occasion the writing tended to become automatic with increase in horizontal magnitude (one signature is 165 mm. in length); increase in height of one space letters; and decrease in height of capitals.

Descriptive Summary (*A*).—The name was rarely written automatically. Attention usually went to the writing of it.

TABLE X.

WRITING OF NAME, NORMAL CONDITIONS. SUBJECT R.

Averages made from 50 trials, one sitting.

Rapidity, 6.116s.; M.V., 1748. (Marked R. in table.)

Length in horizontal, whole name, 88.42 mm.; M.V., 9.27 mm. (Marked L-h. in table.)

Height of capitals (2), 9.42 mm.; M.V., .9007 mm. (Marked H.C. in table.)

Height one space letters, 1.66 mm.; M.V., .178 mm. (Marked H.S. in table.)

Writing of Name—Distraction Experiments.

	R.	No. of Lapses.	No. Counted or Read.	Measurements in mm.			Control Processes.
				L-h.	H.C.	H.S.	
Normal	6.2			104	15	2.7	
I.[59] A.	5	0	27	119	16	4.5	Grm report. Slight visual control.
I. B.	5.3	0	26	105	16.3	4.9	Grm report. Slight visual control.
I. B.	5.2	0	30	102	14.3	4.4	Grm report. Slight visual control.
I. C.	5.4	0		103	16.3	3.6	Visual attention. Voice lowered.
Normal	No record						
II.[60] A.	7	0		92	9	2.5	Initial Avm; then automatic.
II. B.	6.6	0		92	11	3.1	Nearly automatic.
II. C.	9	0		87	7.3	2.4	Avm, letter by letter with V-i-r.
Normal	6.2	0		104	15	2.7	
III.[61] A.	5.2	0		95	12.2	4.1	Conscious grapho-motor control.
III. B.	7	0		98	10.5	3.5	Avm, at intervals. Not automatic.
III. C.	4.8	1		124	10.6	3.6	Almost automatic. Attention on reading.[63]
III.[64] C.	6	0		112	12	4	Attention on grapho-motor sensations but little meaning to them.
Normal	6.4	0		83	12.3	2.1	
IV.[62] A.	4.8	1	26	113.5	11.3	3.42	Grm control with V-i-a at intervals.
IV. B.	5.2	0	30	154	13.3	3.54	Initial Avm cue.
IV. C.	6.3	0	31	108	11.3	3.64	V-i-a initial cue.

[59] I. counting aloud and writing, eyes open. A, attention undirected; B, attention on distracting process; C, attention on writing.

[60] II. reading mentally and writing. A, B, C (see note 59).

[61] III. reading aloud and writing. A, B, C (see note 59).

[62] IV. counting aloud and writing, blindfolded. A, B, C (see note 59).

[63] Writing was somewhat disorganized. R did not obey directons.

[64] Throughout distraction experiments I and III there was a slight increase in pressure on pen.

The enforcement of attention to writing was generally a visual enforcement.

The speed of writing was usually increased by distraction; but the effort required in throwing attention on the distracting

process always caused a retardation. When attention went to the writing there was little change in writing rapidity except in III C, where there was a shift from the usual visual control to a grapho-motor and contact control which was felt to be strained. Five (5) lapses occurred in the series.

TABLE XI.

WRITING OF NAME, NORMAL CONDITIONS. SUBJECT A.

Averages made from 50 trials, one sitting.

Rapidity, 4.178s.; M.V., .19576s. (Marked R. in table.)

Length in horizontal, whole name, 90.76 mm.; M.V., 1.88 mm. (Marked L-h. in table.)

Length in vertical, initial 'J,' 18.36 mm.; M.V., .825 mm. (Marked L-v. in table.)

Height of other capitals (2), 7.01 mm.; M.V., .753 mm. (Marked H.C. in table.)

Writing of Name—Distraction Experiments.

	R.	No. of Lapses.	No. Counted or Read.	Measurements in mm.			Control Processes.
				L-h.	L-v.	H.C.	
Normal	5			105	26	11	
I.[65] A.	4	0	18	76	20	7.5	Grm and V-s-r control. Att. on writing.
I. B.	5.8	0	22	73	16	8.5	Initial cue was Grm-i. Visual correction.
I. C.	5	0	29	70	20	8.5	V-s-r control, V-i-a slight.
Normal	5.2			96	28	12	
II.[66] A.	4.8	0	6	80	15	9	Attention on writing.
II. B.	5.6	1	8	80	16	9.5	Grm-s-r with V-i-a control.
II. C.	5	0	4	87	17	9	V-i-a. Visual control throughout.
Normal	4.4			111	23	12.5	
III.[67] A.	4.6	1	9	115	22	12	V-i-a and V-i-r.
III. B.	9.4	0	18	138	22	12	No initial cue. A-i-a in center.
III. C.	16.6	1		133	25	10.5	Attention on grapho-motor and contact sensations which are unmeaning. Break-up of coördination.
Normal	5			105	26	11	
IV.[68] A.	5.6	1	20	80	19	8.5	Two lapses reported incorrectly.
IV. B.	5.9	1	24	78	15	9	V-i-a control throughout.
IV. C.							

[65] I. counting aloud and writing. A, attention undirected; B, attention on distracting process; C, attention on writing.

[66] II. reading mentally and writing. A, B, C (see note 65).

[67] III. reading aloud and writing. A, B, C (see note 65).

[68] IV. counting aloud and writing, blindfolded. A, B, C (see note 65).

TABLE XII.

WRITING OF NAME, NORMAL CONDITIONS. SUBJECT H.

Averages made from 50 trials, one sitting.

Rapidity, 10.662s.; M.V., .3766s. (Marked R. in table.)

Length in horizontal, whole name, 1033.5 mm.; M.V., 6.8 mm. (Marked L-h. in table.)

Height of capitals (4), 4.13 mm.; M.V., .33 mm. (Marked H.C. in table.)

Length of final 'y's' (2), 4.07 mm.; M.V., .555 mm. (Marked L-y. in table.)

Writing of Name—Distraction Experiments.

	R.	No. of Lapses.	No. Counted or Read.	Measurements in mm.			Control Processes.
				L-h.	H.C.	L-y.	
Normal	13.4			117	5.8	9	
I.[69] A.	9.4	0	37	106	5	6.2	Vm & Grm-r at places; largely automatic.
I. B.	10	2	25	136[73]	6.5	7	Automatic, after initial V-i-a cue.
I. C.	10.4	0	27	89	4.9	7.5	The first initial is Vm; heavy pressure on pen. Visual attention.
Normal	12.4	0		116	5.4	7.7	
II.[70] A.	10	2	18	141	4	6.5	Automatic.
II. B.	11	2	12	138	5	6.2	Nearly automatic. Attention was enforced on reading by actual lip movement.
II. C.	14.5	1	18	148	5.5	10	Vm enforcement, syllable by syllable.
Normal	12	0		109	4.6	4	
III.[71] A.	No test						
III. B.	10	1	18	134	4.6	3.5	Almost automatic.
III. C.	17.8	0	4	129	6.2	5	Vm enforcement, syllable by syllable.
Normal	11.7	1[74]		120	4	4.5	
IV.[72] A.	10	1	40	125	5	3.7	Automatic. H. not aware what she had written.
IV. B.	No test						
IV. C.	27.4	0	18	148	6.2	9.7	Initial V-i-a cue for first part of name; then attention was thrown on graphomotor report. From this point on writing became large, childlike and rounded, unlike usual telescoped writing.

[69] I. counting aloud and writing, eyes open. A, attention undirected; B, attention on distracting process; C, attention on writing.

[70] II. reading mentally and writing. A, B, C (see note 69).

[71] III. reading aloud and writing. A, B, C (see note 69).

[72] IV. counting aloud and writing, blindfolded. A, B, C (see note 69).

[73] The horizontal measurement would be longer, if it were not for the omission of two letters.

[74] Lapses often occur in H.'s normal writing.

A's writing showed usually a reduction in size when distraction was present. III (distraction both visual and articulatory offered an exception to this statement. Plate III, 4 (*a*), 4 (*b*).

Mental Addition Test.—A, who found the mental additions easy to perform, made use of visual and auditory-vocal-motor imagery in effecting them. When the eyes were used the writing was controlled largely by the visual perceptual series. There was little effort reported; light pressure on pen; and, toward the center of the series, a slight increase in size of writing, with growing automatism. The speed of writing was slightly retarded.

When the eyes were blindfolded the loss of the perceived result of writing was very evident. Writing became at places more automatic than it had been in any other test, increased in size, and was retarded in speed. Lapses occurred frequently. When attention went to writing it took visual form and introduced conflict with the visual imagery used in the calculations. A reported at times a curious sense of the absence of the graphomotor sensations usually present in writing. (Cf. D, p. 111.)

Descriptive Summary (*H*).—Unless the experimental directions required the focusing of attention on writing, the writing of the name was largely automatic. As in the case of writing the verse, H forced attention on writing her name by concentrating on visual anticipation or visual report, when the distraction was articulatory; by using vocal-motor enforcement when there was visual distraction.

Distraction increased the rapidity with which H wrote her name unless attention was thrown on writing, on which occasions writing became slow and laborious. I C (articulatory distraction) offers the only exception to this statement and in this instance H was able to concentrate perceptually on the visual report.

Many lapses occur in writing the name, ten (10) in this series. Such lapses occur frequently when H is writing with no accompanying distraction. The fifty autographs, taken as a normal series, show seventeen (17) such lapses.

With distraction there was always an increase in the horizontal extent of the writing, except in I A and I C (distraction

articulatory), in which attention was probably focused on visual report. (Attention, perhaps, was on contact sensations and finger movement was used.) There was slight variation in the height of letters measured and such variation as there was, tended toward a reduction in size of writing characters, *unless* attention was focused on *writing,* when writing was greatly magnified. The long time required for writing these latter signatures indicates that the writing in these instances was a hesitant not a running hand. In I C, which offers an exception to this statement, a different method was used to enforce attention and the speed of writing exceeded the normal rapidity.

Mental Addition Test.—This experiment was not tried with H.

It is evident from the foregoing account of the writing of the name under distraction, that the results from this test confirm the conclusions reached from a consideration of the results obtained when the verse was written under distraction. Only a brief repetition of such conclusions will be necessary.

As before the subjects fell into two groups. For B, H and R there was a strong tendency to write the name automatically; but for D, A, S and Y this tendency was very slight, although if the distraction were particularly effective, D and A sometimes succeeded in writing a more or less automatic autograph. Both A and D report on occasion a curious sense of the loss of the normal grapho-motor sensations, a peculiar feeling which to be realized needs to be experienced. As in the test on the verse, there is evidence here that hand-innervation in Y's case demands distinct effort, deliberate volition.

As before, the reagent best concentrated on writing by enforcing the least automatic process. Concentration on writing retarded speed for B, R and H but quickened it for D. The general tendency for mere distraction to quicken writing of the name was noticeable in B, R, A and D. This result is due partly to a surrender to automatism but partly also to what may be called 'psychic pace-making.' For D, the quicker operation (counting for instance) sets the pace and writing is speeded in consequence.

Lapses in writing the name occurred frequently for Y, B

and H; more rarely for D, R, S and A. This parallels exactly the results obtained from the verse.

6. Variations in Size of Writing under Distraction.

It remains to discuss the changes in the size of writing characters under distraction—a subject not touched upon in citing the results from writing the test-verse. A brief reference to the conclusions of other investigators relative to this point may be profitable. As regards the relation of the extent of writing movement to the ease or difficulty of the task imposed on the writer, Diehl[75] found that the extent of the writing stroke decreased under certain conditions of difficulty and also under certain emotional conditions that were unfavorable. He reported an increase in extent when the task was lightened.

Binet[76] in an experiment on modified writing, in which there was substituted for each vowel of the word given to be written the vowel that followed it in the alphabet, found a slight increase[77] in the size not only of the substituted vowels, but also of the unchanged consonants. The amount of increase in size seemed dependent upon the intensity of the mental excitation of the reagent, so that the suggestion is made that the amount of increase in writing-amplitude under such conditions might be used to determine the excitability of the writer. Binet insists that only the excitement induced by the graphic work mentioned can be concluded, without further experimentation, to have the effect mentioned.

In an attempt to analyze the phenomenon Binet urges that modified writing ceases to be mechanical and that the conditions of the experiment provoked an insistence upon the letter to be written, an insistence which produces either a visual or a verbal idea or causes fixation of attention upon the graphic movement. In any case the state of consciousness accompanying the writing is more 'consequential' than under normal conditions. The

[75] 'Ueber die Eigenschaften der Schrift bei Gesunden,' *Psychol. Arbeit.*, Vol. III., p. 1.

[76] Binet: 'L'Écriture pendant les états d'excitation,' *L'Année Psychol.*, 1902, Vol. IX., p. 57.

[77] Binet also cites, but without comment, one case in which modified writing resulted in a reduction in the size of the writing.

intellectual work required in suppression and substitution of letters produced a diffused excitation, but not a disorganizing excitation since it assured a better formation of letters.

Lemaitre[78] and Claparéde[79] repeated Binet's experiment. The former, working with a large number of boys, concluded that the test is a test of excitability. Claparéde, who used himself as subject, explained the result, namely the enlargement of the writing characters, as due merely to the transformation of running into hesitant writing through the arrest of movement, the mental hesitation, induced by conditions such as make running writing impossible.

A study of the tables of the present series with reference to the changes in amplitude of writing introduced by the various distractions makes it evident that the relation between the conditions and the resulting variation in the size of the characters is one of considerable complexity. The measurements given in the tables are, it should be recalled, taken roughly and only on selected letters (except in the case of B's and D's autographs where every letter was measured). The indications, however, are unmistakable.

The following conclusions seem justified: There is an increase in the amplitude of movement as complete withdrawal of attention from writing (automatism) is approximated. This increase in size was evident not only in the autographs obtained from B, R and H, with whom automatic writing resulted frequently, but was also evident in the rare cases of automatic autographs reported by D and A.[80] Such a result is in agreement with Diehl's findings.

Increase in size of characters occurred again whenever attention oscillated in such a way as to induce a separate impulse for the writing of each letter. This result is comparable with that obtained in Binet's test in which running writing was interfered with.

[78] Lemaitre: 'Un Test, basé sur le modification de l'écriture,' *Archiv de Psychol.*, III., p. 389.

[79] Claparéde: 'Remarque sur le grossissement provoqué de l'écriture,' *Archiv de Psychol.*, III., p. 390.

[80] This was particularly true in the tests where mental addition was used as a distracting process. These measurements are not given in the tables.

Decrease in the size of writing resulted in such reagents as A, D, Y and H whenever a distraction process accompanied the writing, *unless* the distraction was so complete that writing approached automatism. Such automatic writing of the name was possible for A and D, although a strong distraction was needed to make it evident. When such automatism occurred in the case of these subjects the increase in amplitude of movement over that found in normal writing was evident, although both A's and D's writing showed a marked decrease in the size of characters under the usual conditions of distraction.

This decrease in the size of writing under distraction is evidently an indication of the effort of attention involved in carrying on voluntarily two processes and it varies from a slight decrease to very great reduction in size.

In general, this curious result is found, that the experiments marked C in the different series show for B, R and H the greatest increase in size; for D, A and S the greatest reduction. The variation from the normal in these opposite directions was often very considerable, yet both groups of subjects had been instructed to give attention to writing so that automatic writing was shut out by the condition of the experiment. The experimental directions resulted for the first group in a break-up of writing coördination, with a separate impulse for each letter, and in oscillation of attention. The second group responded to the conditions with an intensification of the amount of effort.

Decrease in writing amplitude, frequently found in those reagents whose attention went normally to writing, occurred also, although rarely, in the reagents of the other group. For the form which attention upon writing assumed was also influential in determining writing size. Attention upon the visual report or upon contact sensations tends in general, quite apart from distraction of attention, to reduce the size of writing as the writer's experience has shown her many times. On the other hand, if the writer concentrates upon the sensations coming from the hand or arm an increase in amplitude results. The change here is probably due to use of the finger-movement in the first case, and a wrist- or forearm-movement in the other.

Whatever induces such a change in the musculature used will also influence the size of the resulting writing. A complete treatment of variation in size of writing under distraction should include a separate registration of finger- and hand- or wrist-movement such as was achieved by Judd.[81] Even the crude measurements given in the tables indicate that the variation in the height of the one-space letters is not always in the same direction as the variation in their breadth or the height of the longer letters.

The relation of emotional conditions to writing amplitude in the present series is ambiguous. B, R, D and Y showed strong emotional disturbances. R, B and D found the experiments exciting and interesting; Y found them depressing. But no general correlation can be established between the pleasantness and unpleasantness of the experiment and the variation in the amplitude of the writing. The effort of attention involved was a much more important factor. Both Y and D found the tests required effort and for both there is usually a reduction in size. The emotional conditions in the two cases were however very different.

Closely associated with the change in writing amplitude is that of variation in pressure. No effort was made to measure such variation in pressure. It is, however, frequently evident in the result and was sometimes reported by the reagent as a method of enforcing attention. It is very evident in D's writing where it occurs in connection with decrease in extent of movement.[82]

For variations in writing-amplitude, compare Plate III.

7. Conclusion, Part II.

Briefly, then, in recapitulation:—The reagents fell into two groups. The first group (B, R and H) showed a strong ten-

[81] Judd: 'An Experimental Study of Writing Movements,' *Phil. Studien,* XIX., p. 243.

[82] Diehl (*loc. cit.*) found that increased difficulty in the task imposed increased the amount of pressure; and that increased pressure with decreased size of writing and retardation of speed accompanied writing under unfavorable emotional conditions. See also Freeman: 'Preliminary Experiments on Writing Reactions,' *Psychol. Rev.,* Monog. Sup., Vol. VIII., No. 3, p. 331.

dency to write more or less automatically; the second group (A, D, S and Y) a strong tendency to control writing consciously. Distraction and change in direction of attention threw such tendencies into the foreground. The results from the members of the same group are, in general, comparable from the standpoint of method used in enforcing attention; number and character of lapses resulting from distraction; variation in rapidity of writing under distraction; and variation in size of writing under distraction.

A glance at the conclusion of Part I (p. 51 f.) will show that the grouping of the reagents that resulted from the experiments reported in that section of the paper parallels that given in the above paragraph as a result of the tests of Part II.

PART III.

The reports from certain subjects in the tests just described raised the question as to how far the words of the experimenter, who gave the directions what to write, could constitute the writing-cue, particularly in the case of the test on the name or phrase. Again, reagents sometimes spoke of the hand being 'set' to write the given phrase previous to the signal.

The tests now to be described (1) were planned, therefore, for the purpose of testing (*a*) the result on the cue when the signal for writing was delayed; (*b*) the length of time the 'set' described above could last.

Another set of experiments (2) was also planned in order to test further the nature of the different imagery processes and the possibility of pure grapho-motor imagery and to determine the effect of doubling ideational processes apart from the act of writing.

1. Test in Which There was a Time-Lapse Between the Giving of Directions What to Write and the Signal for Writing.

During this time the subject counted aloud by varied intervals.

The series was planned with the purpose of testing the effect of a delayed signal on the initiation of writing. The following questions, particularly, were in mind:

1. What variation in result will occur as the time during which writing is delayed is increased. For instance, will the experimental directions what to write be effective as cue if the time-interval is short, but insufficient as the interval is lengthened beyond a certain point? If so, the effectiveness of the experimental directions to serve as cue should be held in mind, if one would plan a method to test the non-sensory initiation of voluntary movement. Again, is the prolonging of the cue-effect of the experimental directions, if such is found, due to

the production of a 'nervous set' in the writing musculature? During the longer intervals will there be a recurrence of the feeling of 'set' and will this be preceded by the recurrence of a sensory cue of some sort?

2. What difference in results will be effected by variations in the difficulty of the interval used in counting, counting by 13's for instance in contrast with counting by 2's? As the attention is fully occupied by the counting operation, how will consciousness of the phrase to be written be retained? Will it be possible at any point to get hold of a meaning-consciousness that is not in any way sensory?

3. What will be the effect of change in the directions what to write, after the subject has been habituated to writing some particular phrase under the conditions?

Method.—Before attempting to answer these questions, a brief summary of method and results may be given. The subject was told what to write when a second signal should be given. At an initial signal he was instructed to begin counting by given intervals varying in difficulty from 1 to 13 (counting by 1, 2, 3, 5, 10 and 11 was considered easy; by 4, 6, 7, 8, 9, 12 and 13 difficult). The time given to counting before the writing began varied from 1 to 60 seconds. In the majority of the tests the subject wrote his own name; but at certain points in the test, the phrase 'University of Chicago,' or some other simple phrase was substituted for the name. The writing of the name was chosen as test, since, being so automatic an act, any conclusions as to the need of sensory control based on results so obtained would, *a fortiori,* probably hold in other cases. Most of the tests were tried with the subjects blindfolded, so as to shut out visual sensory stimuli as motor cues. A sufficient number of experiments to show that the results are not materially different when the eyes are open was, however, tried. At signal, hand and pen were in position ready to write, but the pen was not in contact with the paper.

Result.—Total number of tests, 146.

Number of times in which there was reported a distinct initial cue at second signal, 102.

Number of times in which the second signal was reported as initiative of writing, 29.

Number of times in which no cue was reported or there was hesitation or difficulty in describing cue, 15. (The writer has included here all reports of 'hand set' as producing movement, and all cases involving introspective difficulty.)

It was the intention of the writer to tabulate the results with reference to the number of times a cue was present in the long and short time intervals and with the easy or difficult counting-intervals, but so great was the individual variation that such a numerical summing up of results had little meaning. The following tabulation of results for the individual subjects makes this evident.

Subject.	Whole Number of Tests.	Number of Times Initial Cue.	Number of Times Signal was Cue.	Number of Times no Cue or ? Cue.
A.	21	16	3	2
S.	18	18	0	0
R.	26	15	7	4
W.	10	7	2	1
Y.	14	10	3	1
D.	33	25	1	7
H.	16	6	10	0
B.	8	5	3	0

It is obvious that had several subjects been of the same type as H the outcome, taken numerically, would have been very different. On the other hand, had more subjects resembled S the preponderance in favor of an initiatory cue would have been even greater, for in the case of S every act of writing was initiated by a distinct visual cue.

Put descriptively the different experimental conditions result as follows. *If the counting operation is easy,* both long and short time-intervals are usually filled with continuous writing-imagery or such images keep recurring after blanks; the imagery is, usually, persistent if the time interval is a short one (R, B, A and S). Whether or not the second signal and recurrent image coincide in time is more or less a matter of chance; for the recurrent cues produce a 'nervous set' of the musculature which dies out only gradually (R and B). For D, H and W counting by the easy intervals was productive of little imagery. D required a distinct cue at the moment of second signal. Sensory material in the shape of visualized

hand and pen was sometimes present for D under such conditions of counting, but such sensory material was felt to be inadequate as cue.

When the counting operation is *difficult,* there is less wealth of imagery. During *long* intervals there is apt to be recurrence of sensory cue which fades and revives; if the time-interval is *short,* the subject reports usually that the signal set off the writing, or that the hand was 'set' for the writing in consequence of a 'cue' got during some break in the counting (B, R and Y); or, again, there is a pause at the close of counting followed by a distinct initiatory cue (B, R, Y and D). S and A had little imagery during counting and at second signal initiated writing with a distinct sensory cue.

Such a summary answers several of the questions raised above. The delay of writing during a period of time that is filled with a more or less difficult mental operation results in a large amount of sensory material that is probably to a certain extent superfluous. The lengthening of the time between signal and signal necessitates a recurrence of cue during counting, or the getting of a distinct cue at the moment of writing. Both the experimental directions and the presence of writing-cue produce a 'set' in the writing musculature which persists perceptibly and, introspectively, can be felt waning. Conditions that favor its recognition are (1) a short time-lapse between signals, this interval being filled with an operation that engrosses attention; or (2) a long time-lapse under the same conditions, when the blanks between the recurrent writing-cues will be filled to a certain extent with the feeling of 'writing-set.' There are, however, individual differences in the frequency with which attention is called to this feeling of incipient innervation. Where the interval between signal and signal was unusually long, subjects sometimes reported muscular fatigue of the hand (R and D). In several instances, the innervation was effective only for the first one or two letters of the phrase and after writing so much, the subject would resort to an articulatory or visual cue.

The test furnished absolutely no introspective evidence for a non-sensory meaning-consciousness. It is true that as ex-

perimental evidence there might be cited the cases in which the second signal was reported as initiating the movement. But these cases are comparatively few in number and the conditions under which they occur usually favor a different interpretation. In three cases (R) the signal came after a long delay during which time writing-cues had occurred again and again. In four other cases (A and Y) the response was a reflex one, as shown by the fact that the subject wrote his name and *not* the phrase that he had been instructed to write. Moreover, the fact that H contributes over a third of the cases under consideration is highly instructive; for H's responses in this, as in other tests, were very automatic, shown in this instance by the jerk of the hand at the signal, with the introspective report that the first part, or the whole, of the given phrase was written before the subject was aware what she was doing; and by the further fact that when the experimenter changed the directions, the signal would at first call out the old movement.

So little evidence in fact is there for a non-sensory consciousness, that when directed to write some of the less usual phrases, the subject had recourse to sensory enforcement in order to maintain consciousness of experimental directions. S, for instance, added to his usual visual cue an articulatory one; R surprised herself by saying *aloud* the phrase she was to write; H made use of visual images—an unusual performance.

An answer to the question as to the result, when the phrase to be written is changed, after the subject had become habituated to writing it, has already been anticipated. Such a change from name to phrase usually caused a momentary conflict, with an inhibition of the original cue or movement. The case of S furnished an exception to this statement, for he showed no tendency to respond in any reflex manner. The change in instructions was evident in his case only by a slightly longer pause before beginning to write and, sometimes, by an enforcement of the cue. The other subjects show differences in the method by which the habitual response was inhibited. H, for instance, would write the first letter or part of the first letter of her name, and only become conscious of her error through a kinæsthetic report of the writing of these letters. After writing

the new phrase two or three times, under such conditions, these initial strokes became her cue for writing the new phrase. For A consciousness of error came through visual report on the letter made.

Y twice wrote his whole name at the giving of the second signal without any consciousness of error, until his attention was called to the fact; another time he became conscious of the error after the first stroke was made; and a fourth time merely inhibited the name-cue (articulatory). The first two errors are of particular interest and probably indicate not a reflex response, but an inadequate cue; for Y, who had previously been wholly at a loss when the signal came, had in these two experiments deliberately attempted to widen the field of consciousness during counting, so as to include consciousness of the hand. The hand, visualized or perceived through sensations of contact or innervation, had been attended to during the interval that elapsed between signals. Such a hand-consciousness was adequate to produce movement at the signal, but not sufficient to initiate the writing required.

At times, the subject instead of responding to the signal with a movement, reacted with an articulatory or visual cue, the inhibition of which was necessary. For R, B, H and A, there was a tendency to respond with a movement; D usually reacted with a name-cue.

Such differences in reaction mark, again, the varying degrees of automatism. In this connection the reflex arousal of an habitual sensory cue raises the question as to the possible meaning of sensory automatism.

2. Description and Timing of Various Possible Writing 'Controls' for the Verse, With and Without Distraction, and Apart from Actual Writing.

The object of such a test was (1) to get material for comparing the time required for manipulating any particular control process and for actually writing the verse; (2) to determine the degree to which any particular process could be slurred and still carry meaning and be 'felt' to constitute an adequate

motor cue; (3) to test, further, individual facility relative to the use of certain prescribed processes.

The following time-readings were obtained for seven subjects. The number of readings reported under each heading, indicates the number of tests.

SUBJECT R.

Overt articulation of verse: 6.9s., 4s., 3.4s. (slurred), 3.8s. (slurred).
Incipient articulation of verse: 3.9s., 4.6s., 3.8s., 2.8s. (slurred), 2.9s. (slurred).
Grapho-motor imaging of verse: 28s., 66s., 65s.
Overt articulation of verse, accompanied by mental counting (auditory-vocal-motor): 7.9s., C. 10;[1] 5.9s., C. 12; 5.2s., C. 5.
Imaging of verse (visual) while counting aloud: 6.8s., C. 31; same, verse mentally articulated, 7.8s., C. 31.

SUBJECT A.

Overt articulation of verse: 7.5s.
Incipient articulation of verse: 5s.
Grapho-motor imaging of verse: 25s. (see description below), 167s.
Overt articulation of verse accompanied by mental counting (articulatory): 16s., C. 10.
Imaging of verse (auditory) while counting aloud: 66s., C. 186.
Imaging verse (articulatory) while counting mentally (visual): 35s., C. 21.
Imaging verse (auditory-articulatory) while counting mentally (auditory-articulatory): 25s., C. 16.

SUBJECT D.

Overt articulation of verse, 7.2s.
Incipient articulation of verse: 4s., 4.6s., 3s., 3.4s., 3.2s. (slurred), 3.8s., 3.6s. (slurred).
Grapho-motor imaging of verse: 192s.
Overt articulation of verse accompanied by mental counting (visual): 12.6s., C. 15.
Imaging of verse (auditory-articulatory) while counting aloud: 20.2s., C. 48; 19.2s., C. 44.
Imaging verse (articulatory) while counting mentally (auditory): 16.6s.; C. 12; 16.6s., C. 16.

SUBJECT B.

Overt articulation of verse: 9s.
Incipient articulation of verse: 7.8s.
Overt articulation of verse while counting mentally (auditory-articulatory): 21.6s., C. 43.
Imaging of verse (auditory) while counting aloud: 52.6s., C. —; 53.4s., C. 69.
Imaging verse (auditory) while counting mentally (auditory): 18.4s., C. 14.
Grapho-motor imaging of verse: —.

SUBJECT Y.

Overt articulation of verse: 8.4s., 6.9s.
Incipient articulation of verse: 10s., 10.3s. (slurred), 12.7s., 7s. (effort increased, some visual accompaniment).

[1] C. indicates number counted.

Grapho-motor imaging of verse: 91s., over 80s.
Overt articulation of verse while counting mentally (visual): 13s., C. 13.
Imaging of verse (visual) while counting aloud: 22s., C. 29.
Imaging verse (articulatory) while counting mentally (visual): 15s., C. 20.

SUBJECT W.

Overt articulation of verse: 11.2s.
Incipient articulation of verse: 5.4s., 5.2s. (slurred).
Grapho-motor imaging of verse: 34s., 35s.
Overt articulation of verse and mental counting (articulatory): 13.7s., C. 24.
Imaging of verse (slurred articulation) and counting aloud: 12s., C. 14.
Imaging verse (articulatory) and counting mentally (visual): 11s.

SUBJECT S.

Overt articulation of verse, 9s.
Incipient articulation of verse: 7.8s., 5s. (articulation clipped).
Visualizing of verse: 9.4s.
Grapho-motor imaging of verse: 80s. (see notes below), 93s., 93s.
Overt articulation of verse while counting mentally (articulatory): 15.6s., C. 7.
Imaging of verse (blurred articulation) while counting aloud: 31s., C. 55.
Imaging of verse (articulatory) while counting mentally (partly visual): 31.6s., C. 28.

It is evident, with the exception in several cases of tests on grapho-motor imagery, that the time required for the different methods of imaging the verse falls far within the time required for writing it. Therefore Mr. Burnett's[2] criticism against the classical theory of volition on the score that the time needed to obtain a series of adequate motor cues exceeds that required for execution of the intended movement cannot be urged against the efficiency of the ideational cue in writing, at least.

Moreover, even with a distracting or accompanying mental

[2] C. T. Burnett: 'An Experimental Test of the Classical Theory of Volition,' *Studies in Philosophy and Psychology,* pp. 392–401. An unfortunate assumption vitiates Mr. Burnett's method of testing the so-called classical theory of volition; for what theory, however classical (!), would maintain that to a series of repeated movements, a series of cues must correspond, point for point and with quantitative fidelity? It would be more to the point to determine the rapidity with which one could ideate a series (granting a series be necessary) of cues, which, however much slurred, felt adequate to the purpose. Of course in a series of movements such as were considered by Mr. Burnett, a series of anticipatory ideational cues would be unnecessary. The process once initiated, no cue would be needed other than the kinæsthetic or other report from the member moved. The real question at issue would seem to be the necessity in every case of an *initial sensory* cue of some sort.

process, the mental cue series falls, temporally considered, far within the limits required for writing. Certain subjects who found writing under distraction exceedingly difficult, were able to maintain the double mental process with little effort. This result indicates, again, the degree to which awareness, in kinæsthetic or other terms, of the movement executed enters consciousness—to complicate the situation in distracting tests, but, normally, to serve as a control process.

The degree to which a process could be slurred or telescoped and still symbolize the original meaning was imperfectly worked out. In reporting upon suppressed articulation of the verse many subjects called attention to the blurring of the process, and the suggestion on the part of the experimenter that the process be hurried as much as possible resulted in clipping mental articulation, and blurring mental pronunciation. Such slurring of mental, or even of overt, articulation involved articulating only emphatic words or syllables, while between the words thus articulated, intervened muscular tensions, tensions which had meaning only in the sequence taken as a whole. No doubt the maximum possible reduction of such sensory content would issue in a state of consciousness, that approached introspectively from the other end, that is when achieved, would seem to be a pure meaning consciousness, altogether devoid of sensory content.

It was impossible to continue this series of tests to the furthest point of profit. This was the more unfortunate in that the method suggests a way of getting more light upon the relation of auditory to articulatory verbal images, since the slurring of the two processes was by no means correspondent in all cases.

The unequal facility with which the subjects executed the experimental directions in this test is shown by the differences in speed. Again, individual differences were manifest in the manner in which any particular distraction process was dealt with; for in the case of the second, or distracting, process the subject was unconstrained by directions. In so far as the individual variations are merely confirmatory of those observed in the distraction experiments in general, there would be no

value in a second rehearsal of them. The following new observations are of interest. Three subjects (W, R and Y) during this series of experiments laid stress upon the variations in tension in the musculature of the ear, observed during mental articulation. W was inclined to believe that all auditory toning of mental articulation was, in his experience, of such pseudo-auditory quality. Again, a curious variation in the matter of counting-consciousness was brought out in the tests. No slurring of mental counting was possible for W and D, although both were able to slur the verse-pronunciation to a considerable degree without loss of meaning. In fact, counting *mentally,* on the whole, was felt to possess little meaning; both resort, in addition of numbers, to overt articulation, when this is possible. R, D and W report that counting to have meaning must involve consecutive articulation (without slurring); while A, on the contrary, reports that verse-articulation to have meaning must be continuous, while counting may retain meaning though discontinuous.

The most interesting and characteristic results were those obtained in the grapho-motor imaging of the verse. The mode of response in this test at once marked the subject as 'sensory' or 'motor' and confirmed the conclusions reached as a result of the other experiments. A, D, Y and S brought the 'hand' into consciousness only with effort. Actually to imagine writing movement was for these subjects a much more laborious process and one requiring more time to carry out than would overt writing. The natural tendency on the part of these subjects was to image the writing-act in visual or articulatory terms, not hand-kinæsthetic terms, the movement quality being obtained through the serial progression of the images. For R and W, on the other hand, consciousness was preoccupied with kinæsthetic images and sensations and the time needed to image the verse in grapho-motor form was below or approximated that actually taken for writing. Unfortunately, records as to the grapho-motor imagery of B and H were not obtained (both of whom were shown by other tests to be strongly hand-motor). A test on B in another connection (cited below) indicates the way he would, in all likelihood, have responded to the test.

The introspective reports from the different subjects are given below; the details are felt to be instructive.

SUBJECT R.

First Trial.—Hand in lap. It jerked frequently, particularly, R reported, at end of lines. There was actual innervation of the hand and R was not sure that there was any hand-kinæsthetic material other than such sensational-awareness. Besides feeling the hand move, R could see it move. There was, moreover, an indistinct visual report, word by word, of the writing, and complete articulation and spelling out of the longer words. The paper on which the writing was seen was not in the same locality as the hand; it was on the table, tilted at usual angle. Time, 28s.

Second Trial.—Eyes closed, hand resting on table, first finger extended. Tremor in whole arm and finger; actual innervation at difficult places, punctuation places, for instance. Throughout, strong feeling of movement and of inhibition of movement; arm had weak, 'invalid' feeling. Auditory-articulatory accompaniment more laborious and distinct than during actual writing. Visual report, word by word, hazy on grey background. Time, 66s.

Third Trial.—Eyes closed. Hand, grasping pencil firmly, rested on paper laid on table. Contact sensations restricted consciousness of movement. No i's could be dotted or t's crossed because the pencil could not be raised. Area of movement restricted; words close together and all joined; no lining, each line joined last word of preceding line. Paper was shifted from under pencil. But little feeling of movement inhibition. Slight feeling of hand-innervation at beginning of verse; toward close kinæsthetic *imagery* emerged. Time, 66s.

SUBJECT A.

First Trial.—No consciousness of hand. Writing pace was that of reading. Verse was syllabified and seen in own hand-writing, close resemblance to visual report of writing. Letters came in serial groups. Eye movement across lines, probably an actual movement. Time, 25s.

Second Trial.—A instructed to force graphic imagery into hand-terms, if possible. Eyes were closed, pen held in the hand, and hand, but not pen, was in contact with paper. Experiment very difficult. Writing was done from auditory and visual cues, anticipatory. These cues came much more rapidly than the hand could take care of them. There was no image of hand or pen, but there was a slow and laborious visual report *letter by letter,* with some movement-feeling, probably due to actual innervation of hand. There was also eye-movement accompanying the tracing of letters. Time, 167s.

SUBJECT D.

First Trial.—Eyes closed, hand resting on table. There was little consciousness of hand except at places where D deliberately attempted to get graphomotor imagery by bringing hand into the focus of attention. At the beginning of the test, however, no motor imagery was involved. Words were visualized and articulated, letter by letter, with accompanying eye-movement, and movement in tip of tongue (probably actual innervation). Again, hand would be

visualized and run over contour of letters. This visualized hand bore no particular relation to actual hand. Sometimes the visualizing seemed to precede attempted hand-movement, at other times to follow as a report. It was very difficult work. Only distinct hand-motor image came in connection with a capital 'J,' an initial of D's name which is normally executed with a big sweeping movement. Toward the middle of the verse, grapho-motor imagery began to come with less effort. It had a peculiar quality in that there was a striking and distressing sense of the absence of resistance. The experience was like writing in the air or on a yielding surface. Time, 192s.

SUBJECT B.

First Trial.—Eyes closed. Hand clasping pen but pen not in contact with paper. B was instructed to get hand-kinæsthetic imagery involved in writing of name. There was a wealth of tactile, kinæsthetic, and visual images. Effort was needed to hold the real pen still, in order to keep the visualized pen from dancing too energetically.

SUBJECT Y.

First Trial.—Eyes closed, pen held in hand, both in contact with paper. Little consciousness of hand except when it moved slightly. Y ran eyes over the contours of the letters. Y saw the letters as they made themselves but there was little feeling of agency. There was double imagery process, visual and articulatory. The two processes did not keep together, different words would be made by the two methods at different times. Perhaps the visual material was in the nature of a report. Time, 91s.

Second Trial.—Arms clasped. Y was unable to get hand into consciousness. Contact sensations absent in this test reported to be important part of writing-consciousness. Eyes were run over the contour of visualized letters in the attempt to get movement. Y stopped before completing verse. Time, 80s.

SUBJECT W.

First Trial.—Eyes closed. Pen clasped in the hand but not in contact with paper. W experienced an almost irresistible tendency to make actual movement. When this tendency was not present there was mere articulation of verse and no writing consciousness. Perhaps there was a dim visual report for certain letters. Time, 34s.

Second Trial.—Hand held behind back without pen, fingers open, palm out. Fingers moved frequently. Actual innervation. Hand was visualized as stationary but 'felt' moving. The failure to get normal report from writing movements would cause visualizing of hand and perhaps a drifting into a merely articulatory consciousness of verse. Time, 35s.

SUBJECT S.

First Trial.—Eyes closed. Pen in hand and in contact with paper. The test was difficult. Articulation of verse, word by word. When S went slowly, got innervation feeling from arm. To get this, necessary to check articulation speed. Visual report, letter by letter, as if writing. Conscious of hand, but little feeling in it. No eye-movement noticed; letters appeared in place on paper. Time, 80s.

Second Trial.—Innervation in hand actually felt, particularly in line and word-spacing. Inhibition necessary in order to keep from writing. Articulation throughout. Visual report only at times when looked for. Attention strongly on hand. Each time the hand-movement was inhibited, visual image of hand came to focus of attention. Time, 93s.

Third Trial.—Eyes closed. Hand held behind back without pen. Very little feeling of innervation. Principal imagery obtained was a *letter by letter* visual report after articulation. Time, 93s.

3. Conclusion, Part III.

The results from the experiments reported in Part III confirm those reached in Parts I and II. Those reagents shown by the previous tests to be particularly dependent upon grapho-motor processes, in the tests just described respond more reflexly to a delayed signal and show, also, greater facility in the ideating of a grapho-motor process than do the other subjects. The evidence they afford for pure grapho-motor imagery is, however, ambiguous since innervation of the writing musculature was evidently present in many instances. Perhaps the best evidence of grapho-motor imagery occurred in the case of D, who with effort succeeded in getting at intervals such imagery quite divorced from sensational consciousness of the hand.

The tests gave no evidence for a non-sensory initiation of writing and showed that in the case of the writing act the time required for ideating a series of writing-cues fell far within the time required for writing the verse. The only exception to this statement was found in the ideating of a *grapho-motor* series of cues by S, Y, D and A.

That to a certain extent the extreme difficulty experienced by Y in the distraction tests was due to innervation difficulties and not to the maintaining of a double mental process, was shown by the ease with which he maintained the two processes when not required to write while so doing.

Part IV. Summary and General Conclusion.

1. *Comparison of Results. Parts I, II and III.*

It remains to bring together briefly the results of the tests cited in the different parts of the paper. Part I attempted to throw into relief the control processes utilized in writing by eliminating or embarrassing some particular control. Thus it tested the effect of elimination of the seen result of writing by blindfolding the subject; the embarrassment of the motor control through changes in the grapho-motor report introduced by requiring the reagent to write with the left hand; the embarrassment of both the visual and the grapho-motor 'controls' by demanding of the subject inverted and mirror-writing and writing under some strained position of hand and arm. These experiments made evident that some reagents (B, R, H and F) were much less embarrassed by change in the visual factors of the situation than were D, A, S and Y. Moreover, the control in the case of the former group of subjects proved to be much less conscious than that of the latter. When the break-up in the motor coördination was sufficient to demand the acquiring of a new writing-reaction, the former reagents tended to use consciously more motor material than did the latter, for whom the break-up usually occasioned an intensification of the visual control. Quickness in adaptation to the new requirements, when the break-up was considerable, was, however, not wholly dependent upon the sort of imagery used, but was a function of other factors not determined. Only so long as the grapho-motor habit permitted an automatic response, were the reagents of the first group as a whole superior to those of the second. The limits within which the writing automatism could function differed considerably in individuals of the first group.

In the distraction experiments of Part II the problem was no longer one of the method used in acquiring a novel writing

habit, or of the limits within which the old writing habit could function, but a question of the method by which a double process could be maintained. The reagents fell, however, into exactly the same groups as before. Distraction with those of the first group caused a lapse of writing consciousness, so that the writing went on automatically or with control at intervals. The accuracy of the writing under such conditions depended upon the specific conditions. If the distraction were particularly effective, accurate writing could often be maintained for several seconds at a time. An intermittent distraction allowed oscillation of attention which was productive of errors. With the reagents of the second group, for whom writing was less automatized, loss of writing-consciousness occurred rarely. Writing was consciously controlled. Distraction did not, in reality, take place at all; either there was deliberate and constant oscillation of attention, or else the reagents succeeded in synchronizing the two processes carried on. When successful, the latter process was an effective but laborious way of meeting the situation. The attempt to throw attention upon different points in the situation emphasized the grouping of subjects already cited. The first group gave attention to writing only with effort and usually resorted to some indirect means, such as the vocal-motor, for enforcing the writing consciousness. The second group, whose attention focused on writing naturally, concentrated on some more intimate factor of the writing act, such as the visual report or the grapho-motor sensations.

A further complication was introduced by the fact that for some reagents the distracting process appealed to automatized habits. A working out of the control processes in a different act, say that of speaking, would probably cause a re-grouping of the subjects.

Some interesting facts as to the nature and functioning of the different imagery processes were obtained from the distraction experiments. The individual records give these in full.

Part III confirmed the conclusions of Parts I and II. The reflex response to a signal, when the response was delayed and the interval between the giving of the experimental directions and the signal for writing was mentally occupied, emphasized

the automatic character of the reaction of the first group. The members of the other group required a new cue before beginning to write. The subjects of the first group, again, were able when required to do so, to get grapho-motor imagery, although results were complicated by the hand-innervation which resulted from thinking about the process of writing. The other group ideated the act of writing in visual and vocal-motor terms and, unless forced to do so, did not bring hand-movement into the situation.

The agreement in the results of the several tests is striking, when the possibility of error in introspection and of failure to follow experimental directions is considered. The agreement under such varied conditions should weaken any criticism that would discount the results as the forced products of experimental conditions.

The bearing of the tests upon the questions raised in the introduction to the paper has been emphasized in the course of the discussion. To recapitulate briefly: (1) The experiments offer some evidence for the existence of grapho-motor imagery, but this evidence is not unambiguous. (2) Certain results suggest the possibility of complete dissociation of auditory and vocal-motor imagery; but, again, the evidence is not conclusive. (3) No evidence was found for the initiation of a *voluntary* act of writing without a sensory cue of some sort. (4) Throughout the whole series of experiments, the *report* coming from the writing in terms either of kinæsthetic or visual sensations and images, proved to have a highly important function as part of the writing-cue. (5) When automatic writing occurred, it was, apparently, purely physiological in character. (6) Pen errors frequently resulted from a lapsing of the grapho-motor report from the writing and were most often found in reagents of the first group. (7) Complete distraction of attention for any length of time occurred but rarely. The production of such a complete distraction for any one individual demands consideration of the attentional value of the different sense processes for that individual.

2. *Mental Types.*

As to the bearing of the individual differences brought out in the tests upon general mental types but little can be said. The main difference between subjects was the extent to which writing was automatized and the degree to which the reagent allowed conscious direction to lapse. It would be interesting if one might cite this as a general tendency on the part of each particular reagent, and label the individual subjects as 'sensory' or 'motor,' using these terms as Baldwin uses them in his discussion of mental types.[1] It is obvious, however, that such a conclusion could be drawn only after a test of the same subjects in various different acts. It does not even follow that the imagery control would remain constant for any one individual if the act tested were changed. A shift from a verbal to a concrete situation might well cause a shift in method of control. To a certain extent, however, the results seem to have a general significance. Y and S both report slight tendency to automatism in general. They do but one thing at a time, and give careful supervision to their actions. On the other hand, H and R report that their actions become well automatized. Absent-mindedness occurs frequently in the case of H.

Again, the question of quickness in adaptation to new conditions is interesting. R., whose ease in meeting the requirements of the experiments was particularly noticeable, possesses also great adaptability in general. D. was slow in adapting herself to the new conditions. This is also a general characteristic.

3. *Speed, Mean Variation and Appearance of Writing.*

The number of subjects was too small to permit drawing any conclusions as to the relation between the writing control and the appearance and speed of writing. Yet the following facts are of interest. A, whose control was visual and often anticipatory, was by far the most rapid writer of the nine tested. B (motor) came second. S (visual in control) gave the lowest mean variation in speed; B the highest. The relative position of these two subjects remained the same whether the mean variation in speed was obtained from the different trials in

[1] Baldwin: 'The Story of the Mind,' Chap. VIII.

writing the verse on different days, or got from the series of fifty autographs written the same day.

Undoubtedly some correlation exists between the appearance of any particular individual's handwriting and his method of control. But tests on such a small number of subjects can only be suggestive. In general, those subjects strongly dependent upon grapho-motor sensational control wrote a more flowing, a freer hand than did the other subjects. A tendency toward diminution in the size of characters was most noticeable among subjects of the second group. So far as excellence of penmanship is concerned probably S and R would be cited as producing the most effective results. S. was often preoccupied with a visual copy which he consciously (and conscientiously) imitated. Clerical work has emphasized this tendency. R, who was strongly dependent upon grapho-motor control, wrote a more flowing and more individual hand, slightly more rapid than that of S but more variable both in speed and appearance. A, who relied to a considerable degree upon visual anticipation, was apt to slur the formation of letters, particularly after a word was once safely initiated. There is apparent throughout impatience at being delayed by the necessity of writing at all. H's writing shows a blurring of details, and often exhibits a tendency to graphic stammering. B (control grapho-motor) wrote a rapid and perfectly unambitious hand that gave no evidence of visual elaboration. The writing of both Y and D improved in quality when visual supervision was given it.

Again, the number of reagents was too small to give much significance to a grouping based on sex. Of the nine subjects tested four were women; five, men. Three of the women and two men constituted the first group of subjects, who were dependent upon grapho-motor sensational control. One woman and three men composed the other group, who gave visual attention to writing. The proportion in the two groups is not in accordance with Gesell's[2] conclusion that girls (and women) are in writing, more preoccupied with a visual standard than are boys (and men). Diehl[3] found that women wrote a larger

[2] 'Accuracy in Handwriting as Related to School Intelligence and Sex,' *Am. Jour. of Psychol.*, Vol. XVII., p. 394.

[3] *Locus citus*, p. 61.

hand than men, wrote more rapidly and with greater ease—a description which sounds like dependence upon grapho-motor control. But in the present series, the most noticeably small copy was written by a woman.

A detailed test of a large number of individuals would undoubtedly yield characteristic results as to the relation between writing-control and sex, and writing-control and general appearance of penmanship.

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Cs Ryoakum 9.

N. L. D. Bingham 3a.

N. L. D. Bingham 7a.

James R. Angell 4a.

F. Loraine Pickerton 4.b.

PLATE I. Nine autographs of one reagent, written under nine different conditions. Signatures in mirror-writing have been etched in the reverse. 1. Normal, right hand, eyes open. 2. Normal, left hand, eyes open. 3. Right hand, blindfolded. 4. Left hand, blindfolded. 5. Right hand, mirror-writing, blindfolded. 6. Left hand, mirror-writing, blindfolded. 7. Right hand, mirror-writing, eyes open. 8. Left hand, mirror-writing, eyes open. 9. Right hand, inverted writing, eyes open. For comparison are added 7 (*a*) and 8 (*a*), the right and left hand mirror-writing, eyes open, of another subject; also 4 (*a*) and 4 (*b*), the left hand blindfolded writing of two other subjects. The control for Y. and A. was visual; for B. and R. motor.

All leap-years save it twenty nine
which hath but twenty ~~eight~~ eight in five
Excepting February alone
All the others thirty one
April, June and November
Thirty days hath September (

I

PLATE II. Specimens of inverted writing. I. Inverted writing by F., written from right to left. Control, automatic motor inversion. Time required for writing, 4 min. 27 sec.
II. Inverted writing by S., written from left to right. Control, visual anticipation: letters visualized right, then inverted and reversed. Time required for writing, 7 min. 22 sec.
III. Inverted writing by W. Control, conscious motor inversion. Time required for writing, 22 min. 3 sec.

PLATE III

W. P. Bingham 1a.

W P Bingham 1b.

James R. Angell 2a.

James R. Angell 2b.

Florence Richardson 3a.

Florence Richardson. 3b.

James R. Angell 4a.

James R. Angell 4b.

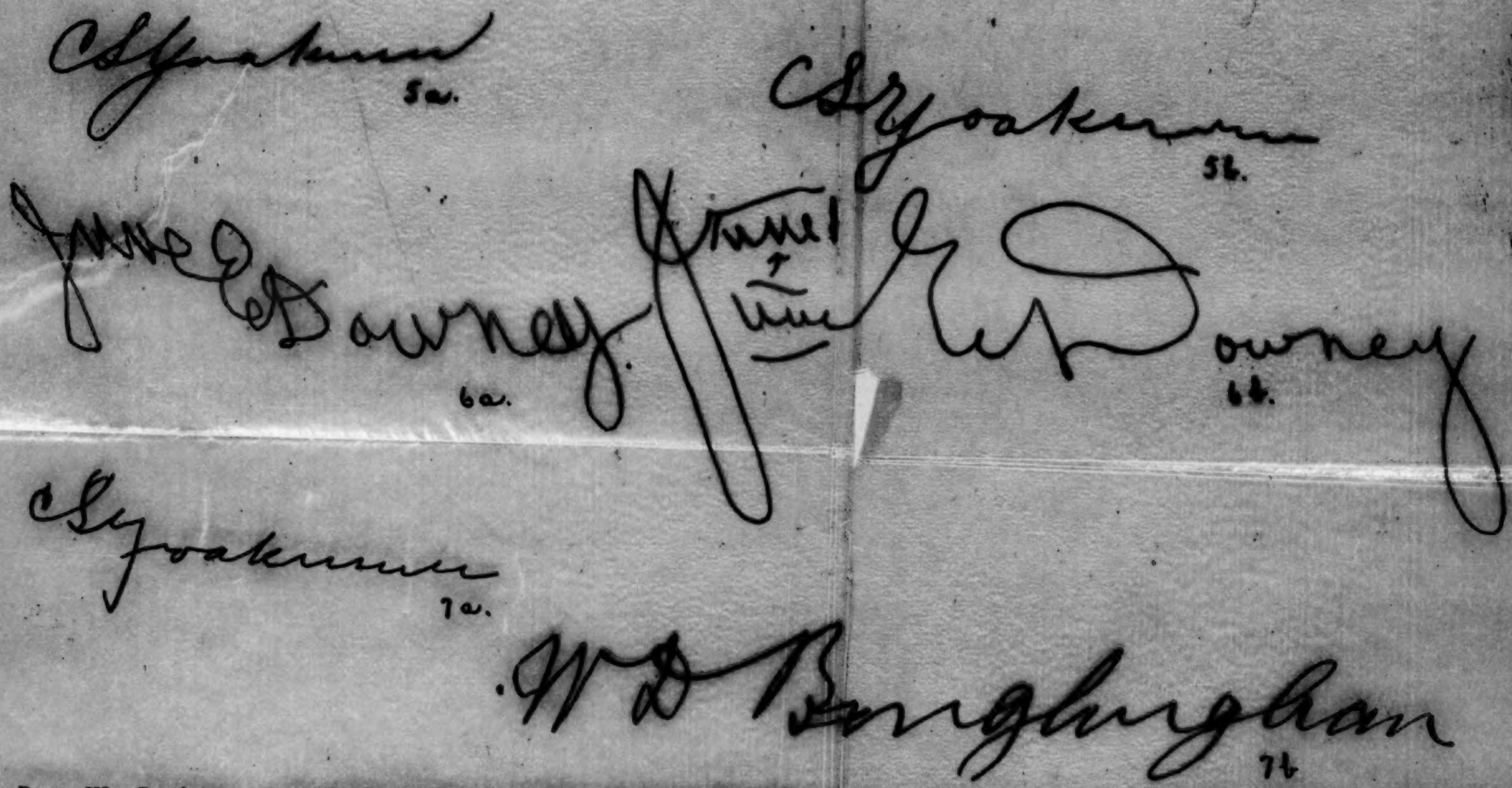

PLATE III. Specimens 1–5, autographs written (*a*) normally; (*b*) during distraction. 1 (*a*) Normal; 1 (*b*) distraction, reading aloud, attention on writing; 2 (*a*) normal; 2 (*b*) distraction, counting aloud, blindfolded, attention on writing; 3 (*a*) normal; 3 (*b*) distraction, counting aloud, eyes open, attention on counting; 4 (*a*) normal; 4 (*b*) counting aloud, eyes open, attention on writing; 5 (*a*) normal; (*b*) distraction, reading aloud, attention on reading.

6 (*a*) Left hand autograph, written blindfolded; 6 (*b*) A right hand reproduction of the visual report received while writing 6 (*a*), the reproduction being written eyes open.

7 (*a*) and 7 (*b*) Autographs written blindfolded by subjects occupied with mental arithmetic.